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the use of phylogenetic methods*

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Abstract

Pottery *Ancestories*: comparing ceramic evolution in the Eastern Mediterranean and south-east Arabia during the Middle Bronze Age (ca. 2000-1550 BC) with the use of phylogenetic methods

Michel de Vreeze

Thesis abstract

This thesis uses phylogenetic methods such as cladistics to address and reevaluate the evolution of ceramic data. Evolution is often implied in ceramic studies but its exact operation in relation to cultural transmission is rarely specified. This thesis asks how phylogenetic methods can be used to study ceramic evolution and how these can reform our perception on the narrative of ceramic change. It does this by forming a theoretical approach based on current anthropological and archaeological theories on ceramics, in conjunction with insights from evolutionary methods. A synthesis of ceramic theory tries to outline the different theoretical approaches and how they might fit with evolutionary perceptions of material cultural change. It suggests that the *chaîne opératoire* of ceramic production is critical in identifying ceramic characteristics to use in evolutionary analysis, and forms the key conceptual framework to address the meaning of ceramic evolution relating to cultural processes. Subsequently the methodology and application of phylogenetic methods is discussed. The following chapter uses a phylogenetic approach based on the general idea of ‘descent with modification from a common ancestor’ to gain insight into the suggested evolution of Tell el-Yahudiya ware in the Eastern Mediterranean. A second case study focusses on the Middle Bronze Age in south-east Arabia and examines the evolution of Wadi Suq vessels, focussing on shapes associated with communal drinking. In the discussion, the results of both areas are brought together and synthesized with a view to evaluating the use and application of phylogenetic methods and their implications for our understanding of ceramic development and what they reflect in terms of the distinct social changes in these regions. Finally, the thesis seeks to evaluate both the use of evolutionary approaches to ceramic change, and the challenges these methods pose to the way archaeologists have traditionally processed ceramic data and analysed ceramic change.

Pottery *ancestries*: comparing ceramic evolution in the Eastern Mediterranean and south-east Arabia during the Middle Bronze Age (ca. 2000-1550 BC) with the use of phylogenetic methods

Michel de Vreeze

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Table of Contents

Abstract.....	1
Pottery <i>Ancestories</i> : comparing ceramic evolution in the Eastern Mediterranean and south-east Arabia during the Middle Bronze Age (ca. 2000-1550 BC) with the use of phylogenetic methods.....	1
Pottery <i>ancestories</i> : comparing ceramic evolution in the Eastern Mediterranean and south-east Arabia during the Middle Bronze Age (ca. 2000-1550 BC) with the use of phylogenetic methods.....	2
Table of Contents	3
List of illustrations	14
List of Tables	17
List of abbreviations	19
Acknowledgments	22
Chapter 1: Introduction	25
Setting the stage: The Eastern Mediterranean and the Arabian Gulf in the Middle Bronze Age.....	25
1.1 Setting the stage: The Eastern Mediterranean and the Arabian Gulf	25
1.1.1: Tipping the scale	25
1.1.2: Second intermediate period and the Hyksos: a corrupted narrative.....	27
1.1.3: The Arabian Gulf.....	27
1.2: Evolutionary methods and the narrative of ceramic evolution	28
1.2.1: Thesis Aims	28
1.2.2: Gathering branches	29
1.3: Objectives and thesis lay-out	30
Chapter 2	32
Towards an integrated theory: Anthropology, archaeology and evolutionary approaches to ceramic change.....	32
2.1: Introduction	32
2.2: Specialisation as a driver for evolution.....	33

2.2.1: Specialisation in pottery production	33
2.2.2: Specialisation, demand and evolutionary pressure	34
2.2.3: Specialisation and the feasting ‘niche’	34
2.2.4: Organizational scales of specialisation: units of evolutionary analysis.....	35
2.2.5: Specialisation and seasonality.....	36
2.2.6: Integrity of production: specialisation and standardization.....	36
2.2.7: Attached and independent specialists	36
2.2.8: Indirect evidence for specialisation	38
2.2.9: Standardization and variation.....	39
2.2.10: Emic and mechanical standardization.....	39
2.2.11: Efficiency	40
2.3: Skill	41
2.3.1: Skill, age and gender	42
2.3.2: Wheel fashioning and wheel-throwing.....	43
2.3.4: The use of the wheel and efficiency	45
2.3.5: The agency of the wheel	46
2.3.6: The <i>chaîne opératoire</i>	46
2.3.7: <i>Chaîne opératoire</i> and a conceptual basis for descent with modification	47
2.3.8: The <i>chaîne opératoire</i> and selective pressure	49
2.4: Stylistic variation and the role of decoration	49
2.4.1: Drifting Decoration? Style and function: a false dichotomy.....	49
2.4.2: Style, decoration and social interactions	51
2.4.3: Learning and innovation and units of analysis	52
2.4.4: Modes of transmission within ceramic production.....	52
2.4.5: Environmental constraints.....	55
2.4.6: The conservative nature of ceramic production	56
2.4.7: Seasonality.....	57
2.4.8: Gender divisions	58

2.4.9: Differences in transmission of ceramic character traits: visibility and malleability	58
2.5: Agency and Materiality	61
2.5.1: Agency of object vs. Agency of person	61
2.6: A synopsis: an integrative approach to the evolution of ceramic production	67
Chapter 3	71
Methodology	71
3.1 Cultural evolution	71
3.1.1: Evolution as a metaphor or explicit framework	71
3.1.2: Criticizing tree-thinking	73
3.2: Vertical, diagonal and horizontal transmission	74
3.3: Transmission Isolation Mechanisms	75
3.4: Units of transmission	75
3.5: Problems and challenges	76
3.6: Phylogenetic methods: Cladistics	77
3.6.1: Choosing taxa	80
3.6.2: Choosing characters	81
3.6.3: Parsimony	82
3.6.4: Qualitative vs quantitative characters	84
3.6.5: Independence of characters	84
3.6.6: Choosing an outgroup	85
3.7: Types of character and transmission	85
3.8: General methodology: Character coding in ceramic studies	86
3.9: Cladistic software: PAUP*	87
3.9.1: Branch and bound and heuristic search	87
3.9.2: Tree length	87
3.9.3: Consensus tree (different types, Majority rule, strict, semi-strict)	88
3.9.4: Testing validity	88
3.9.5: Consistency index (CI)	88

3.9.6: Retention index (RI)	89
3.9.7: Bootstrapping.....	90
3.9.8: Reticulation: horizontal transmission and net-like patterns of evolution	90
3.10: Software: SplitsTree4	91
3.10.1: Testing validity in phylogenetic networks	92
3.11 Character reversal/atavism.....	93
3.12: Long-branch attraction	93
Chapter 4	95
The evolution of a Middle Bronze Age decorative ware: Tell el-Yahudiya as a case study	95
4.1: Introduction	95
4.2: The history of the study of Tell el-Yahudiya Ware: a synopsis.....	101
4.2.1: Early stages: recognized as a separate ware	101
4.2.2: Origins and ethnic identification: the Hyksos.....	102
4.2.3: Middle Bronze I Middle Kingdom traditions: Merrillees and his ‘Lisht ware’	105
4.2.4: Systematic classification and chemical analysis.....	106
4.2.5: Early Provenance studies of Tell el-Yahudiya ware.....	110
4.2.6: Recent provenance studies	110
4.2.7: Tell el-Dab’a fabrics	112
4.2.8: The Tell el-Dab’a excavations and their impact.....	112
4.3: The Dataset.....	115
4.3.1: The assemblage	115
4.3.2: The Context of Tell el-Yahudiya vessels.....	118
4.3.3: Stratigraphy and chronology, a heated debate around Tell el-Dab’a.....	120
4.3.4: Tell el-Dab’a and the debate on the synchronization of East Mediterranean chronology	122
4.3.5: The fundamental problem of dating the Dab’a phases.....	123
4.3.6: Overlap in rule of Second Intermediate Period dynasties	125
Part II: Phylogenetic analysis of Tell el-Yahudiya juglets	129

4.4: Methodology.....	129
4.4.1: Choosing characters and taxa.....	129
4.4.2: Dependency of characters	129
4.4.2: Tell el-Yahudiya juglets and the controversy surrounding the wheel	130
4.5: Experiments with the <i>chaîne opératoire</i> of Tell el-Yahudiya juglets.....	131
4.5.1 The influence of coiling.....	134
4.6: Differences in transmission: visibility of characters.....	135
4.7: Levels of change: selective pressure and spatial-temporal levels	135
4.8: Case study 1.....	138
General groups defined in the literature: the idea of evolution between communities of potters	138
4.8.1: Taxa and Characters	139
4.8.2: Characters	140
4.8.3: Cladistic analysis.....	143
4.8.4: Discussion of the results	145
4.8.5: Excluding the Egyptian group.....	148
4.8.6: Excluding the Palestinian group.....	149
4.8.7: Reticulate data: Splitstree analysis.	151
4.8.8: Discussion of the results	153
4.9: Case study 2: The introduction of juglet production at Tell el-Dab'a	156
4.9.1: The Taxa.....	157
4.9.4: The Characters	159
4.9.5: The analysis.....	159
4.9.6: The results	160
4.10: Discussion	165
4.11: Discussion of general results	167
4.11.1: Piriform and biconical juglets and knowledge transmission by Levantine Potters	168
4.12: Case study 3: “a Cypriote ancestor”?	169
4.12.1: Methodology: Taxa.....	170

4.12.2: Taxa	171
4.12.3: Characters	171
4.12.4: Outgroup	172
4.12.5: Ingroup	173
4.12.6: Results.....	173
4.12.7: Discussion	175
4.12.8: Conclusion on the Cypriote potter and evolution of globular Tell el-Yahudiya juglets	179
4.13: Conclusion and discussion on Tell el-Yahudiya evolution	179
4.13.1: Fragrant funerals?.....	183
4.13.2: Symbolic evolution and the reference to ‘Lotus’ and ‘Lily’ in Tell el- Yahudiya vessels.....	185
Chapter 5	191
The Evolution of Wadi Suq ceramics	191
5.1: Introduction: The Wadi Suq period	191
5.2 Geographical extent: south-east Arabia	193
5.2.1 South-east Arabia.....	194
5.2.2 The Indian Ocean and Persian Gulf.....	195
5.3: Periodization and fuzzy boundaries.....	196
5.4: Continuity and change from the 3 rd to 2 nd millennium BC.....	200
5.4.1: Wadi Suq settlement and subsistence	201
5.4.2: Settlement data	201
5.4.3: Settlement scale.....	202
5.4.4: Pastoralism, agriculture and fishing	203
5.4.5: Evidence from isotopic studies	204
5.5: Cause for change.....	205
5.5.1: Magan, Dilmun and the Indus Valley	205
5.5.2: Role of climatic stress: the 4.2 kyr BP event	205
5.5.3: Tomb architecture: single or collective and the ‘underground movement’	208
5.5.4: Evolution of Wadi Suq tombs.....	210

5.5.5: Tomb development at Shimal	211
5.5.6: Transitional Umm an-Nar to Wadi Suq tombs.....	211
5.5.7: Tomb development at Qarn al-Harf	212
5.5.8: Challenge: re-use of tombs.....	213
5.6: Changes in crafts	214
5.6.1: Stone vessels	214
5.6.2: Metalwork	214
5.7: Pendants: a cladistics case study and excursus into Bronze Age connections.....	214
5.7.1 Outgroup.....	215
5.7.2: Ingroup	216
5.7.3: Characters	216
5.7.4: Results.....	217
5.7.5: Individual characters and homology measured by the RI.....	222
5.7.6: Discussion on cladistic analysis of the pendants	225
5.8: Ceramic continuity and change and the evolution of Wadi Suq ceramics	228
5.8.1: Traditional views on ceramic change from the Umm an-Nar to Wadi Suq .	228
5.8.2: A <i>longue durée</i> perspective on ceramic change in Bronze Age south-eastern Arabia	229
5.8.3: Umm an-Nar ceramics and the incipience of Wadi Suq ceramic production	233
5.8.4: Black on Red fine ware	234
5.8.5: Sandy Red Ware	234
5.8.6: Evidence for continuity of ceramic traditions between Umm an-Nar and Wadi Suq	236
5.9: Wadi Suq ceramics	236
5.9.1 General characteristics of Wadi Suq ceramics.....	237
5.9.2 Wadi Suq Fabrics.....	239
5.9.3: The <i>chaîne opératoire</i> of Spouted jars, beakers and cups as attested at Shimal and Qarn al-Harf	243
5.10: Explaining the homogenous features of Wadi Suq ceramics	244

Chapter 6	247
The evolution of spouted jars and beakers/cups at Qarn al-Harf	247
6.1 The ceramic corpus.....	247
6.2 Groups of vessels: Beakers, cups and spouted jars.....	249
6.3 Phylogenetic analysis. Character coding and the Umm an-Nar ‘ancestry’	250
6.3.1: Character coding	250
6.3.2: Umm an-Nar ancestors	250
6.3.3: Ancestral painted motifs attested at Qarn al-Harf and other sites	252
6.4: Continuity and discontinuity in shapes.....	256
6.5: The Umm an-Nar ceramics and agglomerative ancestors	258
6.5.1: Challenges choosing an outgroup.....	258
6.6 Cladistic Analysis	259
6.6.1: General methodology	259
6.6.2: Cladistic analysis of Spouted jars.....	259
6.6.3: <i>Taxa</i>.....	260
6.6.4: Outgroup	260
6.6.7: Results.....	265
6.6.8: Bootstrap analysis.....	265
6.6.9: The Branching pattern	265
6.7: Discussion	267
6.7.1: The CI and RI for individual characters	268
6.7.2: Morphological characters vs. decorative motifs	269
6.7.3: Surface treatment	271
6.7.4: Firing	271
6.7.5: Fabric/ware	271
6.7.6: Decoration	272
6.7.7: Setting ancestral traits to reconstruct the tree.....	273
6.8: Cladistic analysis of Cups/Beakers.....	273
6.8.1: General groups of beakers and cups.....	274

Methodology	274
<i>Taxa</i>	<i>274</i>
<i>The outgroup</i>	<i>275</i>
<i>Characters</i>	<i>276</i>
Results of the cladistic analysis	276
6.8.2: The CI and RI for individual characters	278
6.8.3: Morphology	280
6.8.4: Surface treatment	280
6.8.5: Firing	281
6.8.6: Decoration	281
6.9: Specific types of beakers and cups	282
6.9.1: Taxa	282
6.9.2: Outgroup	282
6.9.3: The Ingroup.....	282
6.9.4: Characters	286
6.9.5: Results.....	286
6.10: General Discussion on the cladistics analysis of Wadi Suq ceramics.....	291
6.10.1: Chronological check	292
6.11: Discussion	293
6.11.1: Cladistic challenges.....	293
6.11.2: Archaeological atavisms:.....	294
6.11.3: Character reversal of the spout.	295
6.11.4: Character reversal of wavy lines as decoration	295
6.12: The role of ceramics in the Wadi Suq period.....	296
6.12.1: Wadi Suq ceramics, an emic style incorporating many local wares?	296
6.13: Conclusion	300
Chapter 7	302
DISCUSSION AND CONCLUSION: CERAMIC EVOLUTION AND THE NARRATIVE OF CHANGE.....	302

7.1: Part 1: insights into material cultural evolution.....	302
7.1.1: The <i>crucial concept of the chaîne opératoire</i>	302
7.1.2: Specialisation.....	303
7.1.3: Independent itinerant craftspeople	303
7.1.4: The skill involved: particularly the use of the wheel	305
7.1.5: The agency of persons and objects; Materiality	308
7.1.6: The visibility of traits and ease of transmission	309
7.1.7: Wheel throwing and decoration	309
7.1.8: Units of analysis	310
7.2: Phylogenetic insights on ‘styles’ and ‘wares’	311
7.2.1: A ‘ware’ in ceramic evolutionary terms	312
7.2.2: A ‘style’ in ceramic evolutionary terms.....	312
7.2.3: A ‘horizon’ in ceramic evolutionary terms.....	313
7.2.4: Phylogenetic fidelity and the distinction between a horizon, style and a ware	313
7.2.5: Is Tell el-Yahudiya ware falsely labelled a ‘ware’?	315
7.2.7: Alternative trajectories with similar outcomes?	317
7.3: Part 2: the ceramic narrative.....	317
7.3.1: The funerary and feasting niche.....	318
7.3.2: Tell el-Yahudiya, The Hyksos and a false narrative?.....	320
7.3.3: Wadi Suq collective burial, consumption and group alliance	321
7.3.5: Evolution, chronology and regionalization in the Wadi Suq period	322
7.4: Part 3: Ceramic data and phylogenetic challenges.....	323
7.5: Future prospects	326
7.5.1: Integration of phylogenetics and the <i>chaîne opératoire</i> approach.....	326
7.5.2: Evolution of artefacts and social exchange networks	327
Appendices Thesis.....	329
Appendix 1: Character list case study 1.....	331
Appendix 2: Character list case study 2.....	335

Appendix 3: Character list case study 3.....	343
Appendix 4: Jericho Tell el-Yahudiya juglets	348
Appendix 5: Wadi Suq pendants	353
Appendix 6: WS spouted jars phylogenetic dataset.....	368
Appendix 7: Phylogenetic dataset general beakers/cups.....	373
Appendix 8: Phylogenetic datasets specific beaker and cup types	377
Bibliography	380

List of illustrations

Fig. 1.1: Location of study area 1: Tell el-Yahudiya ware in the Eastern Mediterranean, and Study area 2: Wadi Suq ceramics in south-east Arabia	26
Fig. 2.1: Scheme of the change from a fragile system to a robust system of ceramic technology.....	53
Fig. 2.2: Scheme showing scale of transmission of ceramic skills.....	54
Fig. 2.3: footed bowl from the late Naqada (3750-3350 BC) and agency	66
Fig. 3.1: Darwin's finches on Galápagos Islands	72
Fig. 3.2: Kroeber's branching tree of life vs. a reticulate tree of human	73
Fig. 3.3: Different types of character traits referred to in phylogenetic studies	79
Fig. 3.4: basic cladogram.....	80
Fig. 4.1: Typical example of early Tell el-Yahudiya ware juglet with reduced fired dark burnished surface and white infilled motifs from el-Lisht.....	96
Fig. 4.2a: Map indicating the distribution of Tell el-Yahudiya ware	97
Fig. 4.2b: Detail of map 4.1a showing Tell el-Yahudiya ware distribution in the Northern Levant and Cyprus	98
Fig. 4.2c: Detail of map 4.1a showing Tell el-Yahudiya ware distribution in the Southern Levant	98
Fig. 4.2d: Detail of map 4.1a showing Tell el-Yahudiya ware distribution Upper & Lower Egypt and Nubia	99
Fig. 4.3: Tree diagram of Tell el-Yahudiya ware, development reminiscent of a phylogeny	114
Fig. 4.4: More recent diagram of Tell el-Yahudiya development based on new insights	116
Fig. 4.5: Scheme showing conventional vs. radiocarbon dates at Dab'a	124
Fig. 4.6: Kutschera <i>et al.</i> 2012: discrepancy conventional dates and calibrated radiocarbon dates	125

Fig. 4.7: <i>Chaîne opératoire</i> of Tell el-Yahudiya juglets Tell el-Dab'a	132
Fig. 4.8: Cladistics analysis of 20 taxa representing main Tell el-Yahudiya groups.....	144
Fig. 4.9: Cladistic analysis excluding the taxa representing the Egyptian group	148
Fig. 4.10: cladistics analysis excluding the taxa representing the 'Palestinian group'	150
Fig. 4.11: NeighborNet plots of main Tell el-Yahudiya groups	152
Fig. 4.12: Length and width plot of piriform and biconical vessel classes from Tell el-Dab'a ...	158
Fig. 4.13: 50% majority consensus tree of piriform and biconical juglets	161
Fig. 4.14: Strict consensus tree of piriform and biconical juglets	161
Fig. 4.15: a phylogenetic network of piriform and biconical juglets.....	163
Fig. 4.16: 'Punctuated equilibrium of throwing juglets on the wheel	166
Fig. 4.17: globular juglet with Cypriote style push-through handle	169
Fig. 4.18: plot of the length and width of the globular juglets.....	172
Fig. 4.19: cladistics reconstruction of globular juglets	174
Fig. 4.20: C-14 dates compared to conventional Egyptian and Levantine chronology	181
Fig. 4.21: 'Branding' of lotus or lily on Tell el-Yahudiya juglets and beakers	188
Fig. 5.1: Main sites with 2 nd millennium BC Wadi Suq remains in southeast Arabia.....	194
Fig. 5.2: Relevant C-14 dates for the 3 rd and 2 nd millennium BC in south-east Arabia.....	199
Fig. 5.3: Consensus tree (Majority Rule) with bootstrap results for Wadi Suq pendants.....	218
Fig. 5.4: Radial phylogram (phylogenetic network) of WS Pendants evolution	219
Fig. 5.5: A network analysis (NeighborNet) of WS Pendants showing dominant groups	220
Fig. 5.6: Map showing the distribution of pendants outside of south-east Arabia	227
Fig. 5.7: Map showing distribution of pendants within Northern Emirates	228
Fig. 5.8: Typical Wadi Suq ceramic assemblage based on vessels found at Qarn al-Harf.....	238
Fig. 5.9: Examples of the finishing of bases of various vessels attested at Qarn al-Harf.	242

Fig. 6.1: Umm an-Nar vessel with stylised caprids from Hili	252
Fig. 6.2: Spouted jars and other vessels from Qarn al-Harf showing ancestral traits	254
Fig. 6.3: A rare spouted jar from a late UNAR tomb (Hili-N)	257
Fig. 6.4: Cladogram as a majority consensus tree based on Wadi Suq Spouted jars from Qarn al-Harf.....	266
Fig. 6.5: Cladogram of general beaker and cup groups	278
Fig. 6.6: Majority rule consensus tree of beakers and cups (22 taxa).....	288
Fig. 6.7: The motif of antithetic caprids and tree on objects around the Arabian Gulf	298

List of Tables

Table 2.1: The visibility and transmission of ceramic traits	61
Table 4.1: Kaplan's groups with defining characters and measurements as published in her work	107-109
Table 4.2: Grave vs non-grave contexts of Tell el-Yahudiya ware vessels (total 699) from Dab'sa and other sites	119
Table 4.3: Tomb vs non-tomb context of Tell el-Yahudiya ware vessels (616) outside of Dab'sa	120
Table 4.4: Chronological phasing of Tell el-Dab'sa according to stratigraphy	121
Table 4.5: The basic steps in the <i>chaîne opératoire</i> illustrated in Fig. 4.7.....	132-134
Table 4.6: The visibility and malleability of ceramic techniques for Tell el-Yahudiya ware vessels	135
Table 4.7: different levels of selection and how this reflects in the Tell el-Yahudiya ware case-studies	137
Table 4.8: General groups of Tell el-Yahudiya ware as devised by Aston and Bietak (2012) used as taxa for analysis.....	141-142
Table 4.9: Retention index for cladogram general groups and selected groups.....	148
Table 4.10: The RI compared to the D-score and Q-residual score for general Tell el-Yahudiya study	153
Table 4.11: The RI compared to D-score and Q-residual for piriform and biconical Tell el-Yahudiya ware study.....	163
Table 4.12: juglets as analysed in cladistics by stratigraphic phasing of Tell el-Dab'sa	164
Table 4.13: occurrence Globular Tell el-Yahudiya ware vessels throughout the Dab'sa phases .	175
Table 4.14: Multiple handmade globular juglets in single tombs	177-178

Table 5.1: The main chronological divisions used for south-east Arabia within the 3 rd and 2 nd millennium BC.....	197
Table 5.2: Results of the Cladistic analysis of Wadi Suq pendants	217
Table 5.3: CI, RI, and number of parsimony steps for Wadi Suq pendants.....	223
Table 6.1: Quantification of types approximate for tombs at Qarn al-Harf	248
Table 6.2: Basic results for spouted jars cladogram.....	266
Table 6.3: Showing the individual CI and RI for the spouted jar cladistic analysis	268
Table 6.4: General information of cladistic analysis for the general beaker groups	277
Table 6.5: Individual characters and CI/RI for general beaker and cup groups.....	279-280
Table 6.6: Scores for the cladistic analysis of the dataset with twenty-two taxa	287
Table 6.7: Individual characters and CI/RI for beakers and cups	289

List of abbreviations

Ancstates	Ancestral (character) states
B&B	Branch and bound
BC	Before Christ
BMAC	Bactria Margiana Archaeological Complex
BP	Before Present
C-14	Carbon fourteen
CI	Consistency Index
Contree	Consensus Tree
D-score	Delta score
EBA	Early Bronze Age
Majrule	Majority rule
MBA	Middle Bronze Age
MK	Middle Kingdom
LBA	Late Bronze Age
NAA	Neutron activation analysis
PAUP	Phylogenetic Analysis Using Parsimony
QAH	Qarn al-Harf
RAK	Ras al-Khaimah
RI	Retention Index
SE	South-east
SIP	Second Intermediate Period

TEY	Tell el Yahudiya Ware
TRIMS	Transmission Isolating Mechanisms
UNAR	Umm an-Nar
WS	Wadi Suq
XRF	X-ray fluorescence

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Where are your monuments, your battles, martyrs?

Where is your tribal memory? Sirs,

in that grey vault. The sea. The sea

has locked them up. The sea is History.

First strophe from the “The Sea is History” by Derek Walcott

(Walcott, D. 1992. Derek Walcott Collected Poems 1948-1984, London: Faber).

Chapter 1: Introduction

Setting the stage: The Eastern Mediterranean and the Arabian Gulf in the Middle Bronze Age

1.1 Setting the stage: The Eastern Mediterranean and the Arabian Gulf

Around 1745 BC, a remarkable shift is noted in the historical records of Mesopotamia describing international trade and connections in the Near East (Broodbank 2013, 367; Magee 2014; Millard 1973; Oppenheim 1954; Potts 2001; Wilkinson 2014b, 304). In a text found at Mari, a line mentions “12 minas or refined copper of Alašiya and of Tilmun” (Potts 1990a, 226). This is the last time the name ‘Dilmun’, as identified with Bahrain and the near Arabian coast, is mentioned in Mesopotamian texts as the main entrepreneur in the trade networks of the Arabian/Persian Gulf. At the same time, Cyprus (identified with Alašiya) is mentioned as a provider of copper. This text can be seen as emblematic of an economic shift in copper procurement in Mesopotamia, from a focus on the Arabian Gulf to the Mediterranean (Broodbank 2013, 367-368; Knapp 2013). While I will not focus on Mesopotamia itself nor go into great details on the copper-trade at this time, the ceramic evolution and narrative of the two case-studies must ultimately be understood largely against these socio-economic shifts and opposite developments in the orientation of major trading networks. It is within this changing Bronze Age world that I set my thesis, looking at two distinct areas which seem in many ways to represent two arms of a balancing scale, balancing with Mesopotamian societies in the middle: the Eastern Mediterranean on the one hand, and the Arabian Gulf on the other.¹

1.1.1: Tipping the scale

The two case-studies examined in this thesis come from opposites sides of this scale. They will focus on two distinct sets of ceramic data from different parts of the Middle Bronze Age (MBA) world (2000-1550 BC). The areas of focus are the

¹ Or as the Mesopotamians would view it: the ‘Upper’ (Mediterranean) and the ‘Lower’ Sea (Persian Gulf/Indian Ocean) (Horowitz 1998, 87).

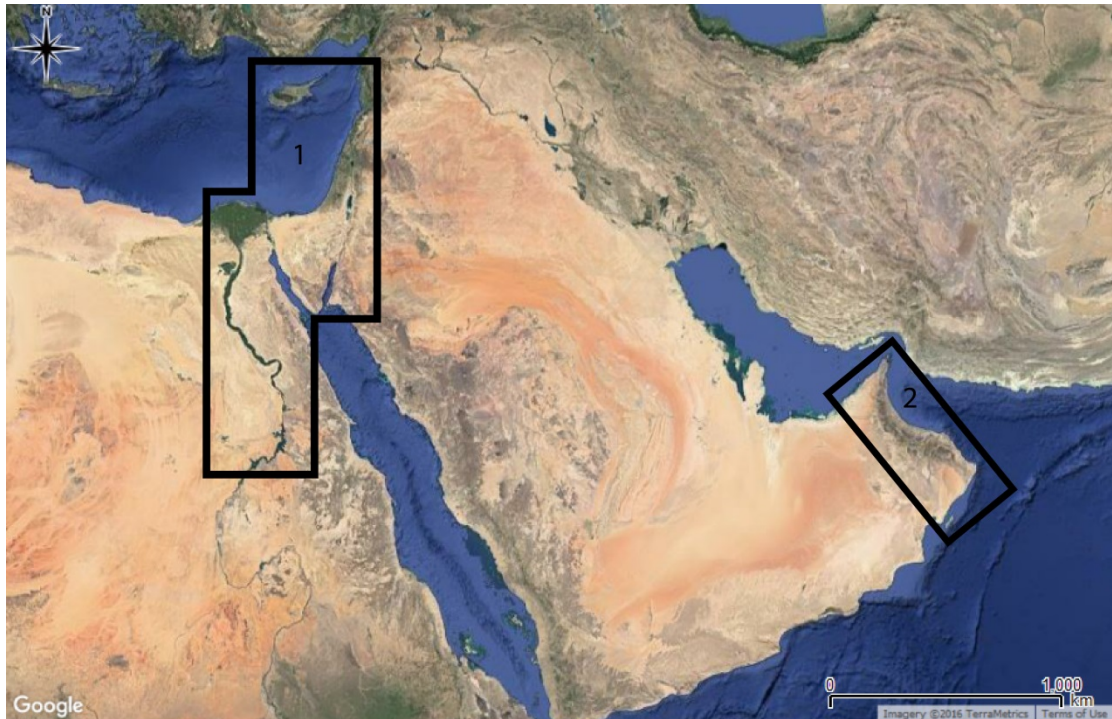


Fig.1.1: Showing the location of the study area 1: Tell el-Yahudiya ware in the Eastern Mediterranean, and study area 2: Wadi Suq ceramics in south-east Arabia (Map courtesy of Google © TerraMetrics).

Eastern Mediterranean on the one hand (Levant and Egypt, Cyprus), focussing on the so-called Tell el-Yahudiya ware of which an evolutionary branching pattern has long been suggested (Aston and Bietak 2012; Bietak 1985). The second case study will focus on ‘Wadi Suq’ vessels from Southeast Arabia, where distinct developments in ceramic evolution are related to processes of regionalization (Magee 2014). Both case-studies are set against the waxing and waning of international communication and seaborne trade and barter, phenomena which became increasingly important in these connected Bronze Age worlds (Broodbank 2013; Magee 2014). However, distinct differences can be noted between the two areas. The case studies will focus on the independent evolution of these particular sets of ceramic vessels due to particular local trajectories, but set against related changes on a larger (geographical) scale. Importantly, in chronological terms these case-studies fall during a period of drastic shifts in the interconnectedness of these regions. Whereas the Eastern Mediterranean goes through a phase of unparalleled ‘international’ contact, barter and trade (Broodbank 2013), Eastern Arabia (the area of the Northern Emirates and Oman) becomes more isolated in spite of undergoing a period of Early Bronze Age interconnectedness during the preceding 3rd millennium BC, displaying clear signs of regionalization (Magee 2014; Potts 1990a).

1.1.2: Second intermediate period and the Hyksos: a corrupted narrative

The 2nd millennium BC Eastern Mediterranean saw an unprecedented mixing of elements and ideas. Broodbank recently asks: “why certain people were tuning to a wavelength more akin to their equivalents’ across the sea than to those of close neighbours beyond the realm” (Broodbank 2013, 348). One of the most eye-catching ceramic classes related to this Middle Bronze Age Eastern Mediterranean sphere is Tell el-Yahudiya ware, the development of which has long been voiced in terms of ‘evolution’, branching, and ‘families’ (Aston and Bietak 2012; Aston 2008; Kaplan 1980). It is thus in this highly interconnected world that the first case study looking at Tell el-Yahudiya ware is set. These small juglets (in their most usual form) with reduced polished surfaces decorated with lime-infilled incisions, form a clear component of decorated ceramic containers which were traded and copied throughout the Mediterranean.

Crucial to the discussion is Tell el-Dab’a, located in the Nile Delta and a key player in this interregional network, called by one author the ‘Venice of the Nile’ (Marcus 2006). Marcus has stressed that the Nile Delta repeatedly functioned as a conduit of new influences and an area of economic and cultural co-influence (Marcus 2006). As such it functioned as one of the dominant ‘gateways’ for influences from abroad (Hirth 1978; Knapp 1993; Marcus 2006). To this day, coastal cities and ports often have such hybrid characters, and it must be remembered that local trajectories in ceramic and general cultural expressions at such settlements can differ substantially from the surrounding region, in terms of nature and internal chronology. However such cities also have a tendency to attract new styles and fashions, from where they disseminate to other regions and communities through local cultural filters. The same could for instance be said about modern cities such as London or Barcelona which function as emblems of a country or region, yet in reality form separate cultural entities from their hinterland while simultaneously functioning as magnets for external cultural influences.

1.1.3: The Arabian Gulf

At the same time, at the other side of the ‘scale’, Southeast Arabia went through a phase of substantial regionalization (Magee 2014; Potts 1990a). The region of south-east Arabia (likely including part of south-east of Iran, around the Strait of Hormuz)

was known as ‘Magan’ and was one of the main providers of copper to Mesopotamia, of which Dilmun became the major intermediary trade entity in the 2nd millennium BC (Carter 2003a; Magee 2014; Potts 1990a; Weeks 2003). At the start of the 2nd millennium BC, a new set of material culture, of which ceramics played important part, takes off. This period is called the ‘Wadi Suq’ (2000-1600 BC) (Cleuziou 1981; Velde 2003). On the basis of excavations at one of the rare tell sites, Daniel Potts observed “the gradual evolution of the Wadi Suq ceramic corpus” (Potts 1990a, 244). However, the majority of Wadi Suq decorated ceramics come from a number of communal tombs used for successive burials which continue practices of monumentality and communal successive burial inherited from the previous millennium, but show distinct local variations. These tombs show similar technical developments (Velde 2003). Recently excavated material from Wadi Suq tombs at Qarn al-Harf (QaH) form the main body of ceramics, which will be analysed using phylogenetic methods to test assumptions regarding ceramic evolution. The end of the Early Bronze Age (2500-2000 BC) in this area has been attributed to various factors, including environmental degradation (the 4.2kyr BP event) and collapse of the trading networks (Edens 1992; Goudie and Parker 2011; Magee 2014; Parker *et al.* 2006). One could perhaps describe this decline as a general scaling down of the social system due to the accumulative effect of rapid environmental change and the disturbance of international trade connections, leading in turn to a period of more regional development, notwithstanding continuing interregional contact. The relation of this process with ceramic developments will be examined.

1.2: Evolutionary methods and the narrative of ceramic evolution

1.2.1: Thesis Aims

The main aim of this thesis is to use an ‘evolutionary looking glass’ in examining two case-studies involving the evolution of particular groups of ceramic vessels, in order to ascertain if such an evolutionary approach could assist in placing these developments within their particular social, environmental, political and economic context. The aim is to show the worth of evolutionary approaches in examining and altering existing narratives of ceramic change. As such it will form a more formal test of ‘ceramic evolution’ as is often implicitly stated in ceramic reports, but rarely explicitly analysed.

In designing the key aims and objective which my thesis would explore, I was wary of constraining myself within a single branch such as ‘evolutionary archaeology’, wanting instead to show the integrative potential of such an approach with other widely established ways of thinking about material cultural change. As such the choice was made to use ‘simple’ methodological assumptions (parsimony) and methods (phylogenetic trees and networks), although more complicated methods and approaches are possible in evolutionary archaeology. An advantage of using quite basic approaches was that many obstacles were easier to recognize and overcome, relating to the quality and accessibility of archaeological data, and implicit assumptions about the evolution of material culture. In this way, the approach in this thesis can point as much to weaknesses as to positive sides of existing archaeological approaches to ceramic change.

The choice to adopt a basic phylogenetic approach did not come easily, and was not intended *a priori*, but forced itself upon the data when conducting the research. The *ratio* for this approach thus became, rather than was intended to be from the start, to examine how the data would hold up using a quite robust model, namely ‘descent with modification from a common ancestor’ (Shennan 2005; Shennan 2002). Moreover, when classifying and coding the data, it became apparent that ceramic data itself has inherent problems, as any other archaeological data. Hence, going to more complex models felt like putting the cart before the horse in the sense that it would start using assumptions which we want to specify in the first place. However, this is not to say that more complex models do not have a future in phylogenetic modelling. Some might suggest that the approach taken in this thesis is quite simplistic, and lacks more evolved approaches in material cultural evolution. This critique can be readily acknowledged. But during the writing of this thesis it became apparent that to cover the basics and expose assumptions and problems in archaeological constructions of ceramic evolution was necessary and would take considerable effort in its own right.

1.2.2: Gathering branches

In the end, one of the goals of the thesis is to confront the problem of poor integration between more ‘traditional’ approaches and evolutionary approaches. This can be illustrated by the recent scepticism voiced by Gosselain on the manner in which neo-Darwinist approaches can help archaeological interpretations of cultural transmission (2008: 151): “I remain unconvinced. My main criticism of such approaches is that

they generally ignore social theories developed by social scientists who do not share a neo-Darwinian agenda—possibly because such theories are considered insufficiently “rigorous” or “secure”....” He further states that: “With few exceptions... ethnographically derived field data, when used, have simply served to validate or illustrate what theory had already ascertained.” (Gosselain 2008, 152). This can be read as a critique that ethnographic or archaeological data only features in an anecdotal way to illustrate an existing theory, rather than using evolutionary theory to explain past dynamics. In other words, it highlights an issue with the lacking integration of different branches of archaeological and anthropological theory with the archaeological data to explain changes in material culture relating to specific cultural processes. It is this idea I try to counter in this thesis. What I have however eschewed in this thesis is the idea Bintliff refers to as ‘ideopraxis’ which would state that the neo-Darwinian lens is the only ‘true’ lens through which to see cultural change (Bintliff 2011). With others, I believe that this will only divide the gap that is already existing, and will fall victim to theoretical ‘niche-construction’ where disciplines lose the capability to communicate ideas and approaches (Mesoudi *et al.* 2006; Mesoudi 2011; 2015; Stark *et al.* 2008).

That being said, the main risk of trying to find a middle way is that this thesis will fall short of its expectations from both ‘sides’ of the spectrum; being too basic for neo-Darwinian purists, and too generalizing for archaeologists sceptic of general evolutionary approaches. I can only hope that I have succeeded in using evolutionary theory more explicitly, yet still pay enough attention to the archaeological data in all its complexity. Whether I have succeeded in bridging a gap in approaches and still add new interpretations to archaeological data, or have fallen victim to exactly the critique as offered by for instance Gosselain, I leave to be judged by the reader.

1.3: Objectives and thesis lay-out

This thesis will start by developing a more extensive theoretical framework based on ceramic ethnographic approaches and material cultural evolution theory. The objective is to form an integrative framework which brings different theoretical branches together, yet trying to avoid falling into the age old trap of ‘reinventing the wheel’ (chapters 2). Chapter 3 will subsequently introduce more detailed discussion on evolutionary theory and the phylogenetic methods used to quantify such

evolutionary processes in material culture. The next three chapters will take two distinct and divergent but broadly contemporary case-studies: Chapter 4 will examine the evolution of Tell el-Yahudiya ware juglets within the Eastern Mediterranean setting, while chapter 5 and 6 will provide the second case study focussing on Southeast Arabia and the related Middle Bronze Age ‘Wadi Suq’ ceramics. These two case-studies will illustrate how similarities and differences in ceramic evolutionary patterns can relate to more broader cultural patterns and how an evolutionary approach may help alter or improve the existing ceramic narrative.

The results of both case-studies will be compared in the discussion and conclusion (chapters 7). This discussion will a) use the insights from the two studies to address the way they can help to re-address documented ceramic change and relate this to the broader narrative of ceramic change using evolutionary approaches as a new viewpoint, b) show the use of an evolutionary approach to ceramic change, c) address issues in the way we process our ceramic data, both personally and within a wider ceramic framework, and address challenges when applying phylogenetic approaches with ceramic data.

Chapter 2

Towards an integrated theory: Anthropology, archaeology and evolutionary approaches to ceramic change

2.1: Introduction

Over the years, many important contributions have been made by anthropological and ethnographic scholars to the study of the role of pottery, its manufacture, use, and discard, across a wide variety of pottery-using societies. Ceramic studies also formed an important part of the ethnographically-informed analysis of societies with an eye on material cultural remains, named ‘ethno-archaeology’ (Costin 2000; David and Kramer 2001; Stark 2003). Recently, a renewed adoption of ethnographic, experimental and archaeological methods combined with evolutionary approaches has been employed regarding the study of learning strategies, specialisation, standardization and cultural transmission (Gandon *et al.* 2014; Glatz 2015b; Roux 2011; 2013). These studies provide key insights into the social dynamics of pottery-making on the basis of which we can infer the meaning of ceramic change in past societies.

This chapter does not attempt to give a full account of the vast body of literature on ceramic theory amassed over the years. Instead, I will select what can be seen as a number of key issues in the study of ceramic production which should be integrated with a phylogenetic approach. The chapter will progress roughly from ‘processual’ to more ‘post-processual’ frameworks (deliberately avoiding ‘taking sides’), starting with insights on specialisation and skill, and ending with discussions on agency and materiality. Throughout, an attempt will be made to show how these insights can be integrated, or differ substantially in perspective to evolutionary approaches. The goal is to create a more integrated evolutionary framework (together with Chapter 3) which builds both on evolutionary principles, and culturally informed processes. I will summarize the main theoretical approaches which will be combined with phylogenetic insights at the end of the chapter, going into evolutionary theory and phylogenetics in more detail in the following chapter.

It is important to remark that this chapter is not the first attempt to bring together the data, nor the most comprehensive, as ceramic studies have featured predominantly in such integrative attempts (Gandon *et al* 2014; Roux 2011; Stark *et al.* 2008).² However I feel that so-far, discussions have too often resided in their specialist niches (see §1.3). The way forward seems to be to approach ceramic change from different theoretical angles without trying to commit to a ‘purist’ or ‘ideopraxist’ singular approach (Bintliff and Pearce 2011).

2.2: Specialisation as a driver for evolution.

2.2.1: Specialisation in pottery production

Specialisation is a term which has been used and discussed abundantly in archaeological theory, often specifically in relation to ceramic production (Costin 1991; Rice 1991; Clark 1995; Costin 2000, 378; Arnold 2000; Costin 2007; Arnold 2008). The interest in specialisation has been strongly connected to its perceived relationship with social structure, being seen as one of the key aspects of more hierarchically organized societies (Costin 2000, 378; Childe 1950; Peregrine 1991; Levy 1998; Glatz 2015a). However, it is important to note that specialisation is not absolute. Following Costin (1991, 2): “Specialization is a relative state, not an absolute one”. Specialisation must thus be placed in its regional, social and temporal context (Orton and Hughes 2013, 145). The key facets of specialisation are that it entails a ‘differentiated, regularized, permanent, and perhaps institutionalized production system’ (Costin 1991, 4). As such the producers (potters) depend on exchange outside of the household to obtain at least part of their livelihood whilst consumers depend on the products they do not produce themselves (Costin 1991, 4; Costin 2001).

Hence, the reciprocal nature of specialisation is instrumental. However, since specialisation is relative, it needs to be qualified depending upon the archaeological case study we are looking at. General aspects of the production process which are key to understand the organization of production are 1) distribution of raw material, 2) nature of the technology, and 3) skill and training (Costin 1991, 2). In this case, Costin argues for a lesser importance of skill and training, but I do not agree with this

² This does not even touch upon studies of this topic for other material cultural groups. I will go into these studies in more detail in chapter 3.

position and agree with her later work focussing more on skill and training and the study of both tangible and intangible *crafts* (Costin 2007: see § 2.3). Skill and training seem to be imperative to specialisation, and are a key element in arguing for specialists, at least on an individual level. This does not always reflect similarly on organization (a pottery specialist in terms of skill does not need not be a specialist in terms of working full-time, for instance). The importance of these aspects of the production process rely on the scale at which one wants to study specialisation; on the level of individuals, or groups of specialists distributed within a society. The nature of demand is crucial to specialisation on the organizational level.

2.2.2: Specialisation, demand and evolutionary pressure

In terms of demand, several characteristics have influence on the level of specialisation, summarized by Costin as 1) the nature of the demand, which relates to the function of the product and the socio-economic role of the users, 2) the level of demand which relates to the number of items in circulation required to satisfy the general demand, 3) the logistics of distribution; the way raw products and finished goods are distributed, and 4) the ‘rationale’ of the producer/supplier, being the main stimulating force behind the production and distribution (Costin 1991, 3). In evolutionary terms we can see that these factors all have influence on the nature of material culture transmission and knowledge of pottery techniques, but most significantly provide the selective mechanisms which steer ceramic evolution. As such they provide the ‘selective pressure’ which is a prerequisite for the evolutionary approach of ‘descent with modification from a common ancestor’ (Shennan 2005).

Specialisation can be defined on multiple levels, relating to the position of a group or to individual skills. Thus specialisations can be defined along spatial and temporal criteria (location or time-management) and relate to levels of skill displayed by an individual craftsperson.

2.2.3: Specialisation and the feasting ‘niche’

Numerous studies have more recently argued for a relationship between specialisation and the use of ceramic vessels in feasting and display (Berg 2011; Costin 2007, 153; Dietler and Hayden 2001; Doherty 2015; Glatz 2015a, 23-24; Spielmann 1998; Spielmann 2002). As Arnold documents ethnographically, festivities surrounding ancestors can result in a significant rise in demand, such as attested in the ‘Day of the

Dead' in Mexico, and the relative small size and low skill involved make these vessels particularly popular to produce among seasonal potters (Arnold 2008, 108). Similar processes might be expected in both our case-studies as Tell el-Yahudiya juglets, and Wadi Suq ceramic vessels are both predominantly known from tomb assemblages, in which both feasting and mortuary practices played a large role (see subsequent chapters).

One key stage in communal sharing of foods and drinks incorporating ceramic vessels surrounds funerary rites, as these are intrinsically connected (Pollock 2003; Tyson-Smith 2003; Nelson 2003). This offers a particularly strong social explanation of ceramic change which would be mediated through potters adapting their techniques to rising demands and has to be evaluated whenever dealing with funerary assemblages. In evolutionary terms, we could thus argue that such feasting activities, or communal gatherings, provided particular 'niches' which a given ceramic type might fill (Laland and O'Brien 2010).

2.2.4: Organizational scales of specialisation: units of evolutionary analysis

The key interest relating to specialisation in this thesis is its relation to the transmission of knowledge on pottery making, and a related question on how specialisation influences ceramic evolution. There are a number of factors playing such a role.

Sander van der Leeuw devised five scales of production which have found their way into archaeological descriptions which have become 'household' names in ceramic studies (van der Leeuw 1977, 144; Costin 1991; Orton and Hughes 2013). These units can be organized hierarchically from low specialisation to highly specialised: 1) household, 2) individual industry, 3) household industry, 4) village industry, 5) Large-scale industry. Costin prefers to re-formalize these different scales of production on the basis of four general parameters, namely the context, concentration, scale and intensity of production (Costin 1991, 8). These parameters are affected by social, economic, political, and environmental variables (Costin 1991, 8).³ Importantly, Costin adds that specialisation can be defined on the basis of the

³ Her categories are defined as 1) individual specialisation, 2) dispersed specialisation, 3) community specialisation, 4) Nucleated workshops, 5) Dispersed corvée, 6) individual retainers, 7) Nucleated corvée, and finally 8) Retainer workshops (Costin 1991, 8-9).

quantity of specialists (either a single potter or a potter working in a group) and the way specialists are distributed within the wider society.

2.2.5: Specialisation and seasonality

There is a third important division, and this one is temporal. Seasonality is important in defining potters as specialised or not. Arnold shows the problem with the definition specialism from part-time potters (seasonal) to full-time craft specialists (during the entire year). Accordingly, the skill of a potter does not necessarily have to be higher when part-time opposed to full-time. As Arnold (1985: 19) suggests: “highly evolved and specialized part-time potters may often live on the edges of society both socially and economically”. As we will see, Arnold works on these same premises regarding specialisation, offering a more explicit evolutionary framework (Arnold 2008, 2-16). Thus, in order to qualify the ‘selective pressure’ relating to the evolution of ceramics, these four general tenets can be partly or jointly responsible. Arnold argues forcefully that it is the unit of production of a group of potters (within a workshop) that we should focus upon when analysing evolutionary patterns (Arnold 2008). It is thus the *community of practice* we should focus on when discussing the knowledge transmission of pottery making. This is in line with phylogenetic approaches, and will be the (inferred) unit of analysis in this thesis as well.

2.2.6: Integrity of production: specialisation and standardization

Specialisation can be present in various degrees and types, and is not a question of presence or absence (Costin 1991, 4). Very significant for the case-studies offered in this thesis is the difference between ‘attached; and ‘independent’ specialists (Costin 1991, 5). A related theme is the migration of potters. This is important because knowledge transmission can be carried through the intermediary of the artefact itself, or via the potters communicating the knowledge themselves (see below on agency).

2.2.7: Attached and independent specialists

An important distinction is made between attached and independent specialists (Underhill 2003). Costin notes that in pre-industrial societies attached specialists are suggested as producing for the ‘elite’, whereas independent specialists produce more utilitarian goods (Costin 1991, 11; Peregrine 1991). Attached specialists would produce goods which can be seen as status enhancing, being luxury or wealth items such as weapons or wealth generating goods (Costin 1991, 11). However, this

distinction might not be as clear cut, with Middle and Late Bronze Age Mesopotamian potters acting as attached specialists yet mass producing utilitarian pottery. Presumably because this type of pottery formed a key element in the ‘tribute economy’ in the region, associated with the mobilization and storage of various products. Nevertheless, Glatz (2015c) suggests that we should not readily assume the presence of attached specialists, even when high levels of standardization are shown. Moreover, it must be kept in mind that especially in pre-modern societies, the degree to which a good is considered utilitarian or luxury was less absolute in terms of distinction and conceptual categories might actually have overlapped. This is the same argument as the problematic dichotomy between ‘ritual’ and ‘profane’ (Bradley 2005; Brück 1999).

The presence of ‘elites’ in itself can be hard to pinpoint (for instance in 3rd and 2nd millennium BC south-east Arabia, see our case study), thus becoming part of a circular argument in relation to specialisation (see also critique in: Glatz 2015b). One can imagine independent specialists that still catered to the higher echelons of society, even though these individuals or groups cannot be seen as full-blown elites capable of retaining a specialist workforce all year round.

Nevertheless, the distinction is important regarding the transmission of ceramic knowledge, as independent specialists can operate in the form of itinerant crafts people. Such craftsmen can be instrumental in the transmission of technical knowledge over vast geographical space. Alternatively, their knowledge might be safeguarded and protected, and thus limited in transmission, even increasing the value of the objects they produce. This idea is for instance put forth by Valentine Roux, suggesting that knowledge of using the wheel in the Chalcolithic Levant was shared by a limited number of peripatetic specialists (Roux 2008; 2010). Independent specialists need a sufficiently large demand to remain sustainable. Reasons for the increase in demand can be population growth, ease of transport or unequal resource distribution (Arnold 1985; Costin 1991, 12). These selective mechanisms are crucial and will feature as causal explanations for selective pressure within an evolutionary framework. On the other hand, the prime motivator for attached specialists is usually sought in social and political mechanisms, and the presence of an ‘elite’ (Costin 1991, 12).

However, different degrees of specialism might have been present and need to be qualified. For instance, in a recent study on metalworking, Maikel Kuijpers suggests a need to further qualify the term specialist, as there seem to be different categories, being ‘amateur, crafts(wo)man, master and virtuoso’ (Kuijpers *forthcoming*). He thus pleads that we take into account the variability in the level of skill displayed within production. This idea is also relevant to the variability attested in ceramic production.

2.2.8: Indirect evidence for specialisation

A challenge when working with archaeological data is the inherent partiality of it. Often we are left with fragments and have to infer degrees of specialisation without direct physical evidence in the form of specific pottery producing contexts such as workshops, households with traces of pottery tools, kilns, or even wasters (Costin 1991, 18; Orton and Hughes 2013, 145; see Glatz 2015a, 20-21 for a recent overview of evidence in the Near East). In such cases one has to infer the kind of organization responsible using only indirect evidence via the technical attributes of the ceramic. Relatively few workshops are known from the Levant, with an exception of partly excavated kilns associated with Tell el-Yahudiya ware from ‘Afula (Glatz 2015a; Zevulun 1990). Tell Arqa (Lebanon) shows good evidence for a Middle Bronze potter’s kiln (Thalmann 2006, 38-39: Fig. 10). For Southeast Arabia direct evidence of pottery production is virtually non-existent. So far no direct physical evidence of pottery workshops (let alone the potter’s wheel) is known for the entire Bronze Age. The sole exception is an updraft kiln from the Umm an-Nar period (late 3rd millennium BC) which was excavated at Hili (Frifelt 1990). Since we are not dealing with actual physical evidence of pottery production (workshops, tools), but the ceramics produced, we can infer the level of organization and specialisation by the products on the basis of parameters which have been investigated ethnographically and archaeologically. However, these do not appear to be as straight-forward as once assumed. Three main indirect measures of specialisation can be distinguished: standardization, efficiency of production and skill displayed. These three measures are also relevant for our present evolutionary studies as they reflect on variation (which is selected upon, see chapter 3) and transmission of knowledge.

2.2.9: Standardization and variation

A key concept of specialised ceramic production is the degree of standardization (Costin 1991, 33). Two basic assumptions are offered by Costin which go hand in hand with standardization: 1) There will be fewer producers, and more consistency in the techniques applied, 2) The production will be routinized and expected to reflect cost-cutting strategies (Costin 1991, 33). However, standardization cannot be directly equated with specialisation and Costin offers the welcome suggestion that different types of objects can be geared towards uniqueness or standardization dependent on the role they will fulfil, and suggests that this is a basic difference between attached specialists, producing unique objects, and independent specialists catering to more general markets (Costin 1991, 33). Recently experimental studies have offered counter-examples to the somewhat easy equation between high level specialisation and standardization, where the latter cannot be attested easily when measured more thoroughly in quantitative ways (Eerkens 2000; Eerkens and Bettinger 2001; Glatz 2015a, 17; Roux 2003; Sterling 2015).

2.2.10: Emic and mechanical standardization

Costin (1991, 35) advises that we should confine studies on specialisation to “aspects of variability that reflect unconscious patterning, motor skills, subtle differences in technology, and slight differences in raw material.” (Costin 1991, 35). Often metric data is chosen, such as measurements of a vessel or diameter of the orifice, however, this might not always be present when dealing with incomplete ceramic data.

There is a distinction to be made between intentional and mechanical standardization (Costin and Hagstrum 1995). Intentional standardization would entail deliberate choices in size classes, shaping of vessel parts and decoration applied, whereas mechanical standardization reflects unintentional processes of standardization due to consistency in motorized skills. This distinction is useful in the idea of transmission of character traits, as emic standardization would entail deliberate transmission, whereas mechanical standardization would come forth out of practice and the transmission of a particular skill set. This is relevant as the standardization would thus reflect on a certain way of knowledge transmission, one actively transmitted, the other more subconsciously present (but nevertheless transmitted

within a production process). As we will see this is particularly relevant when discussing the use of the wheel.

Valentine Roux (2003) makes a useful distinction between emic and mechanical standardization. Emic standardization would come forth from conscious decisions on shape and techniques, whereas mechanical standardization is subconscious and relates to technical skills (motor habits). Roux concludes that the latter only supersedes principles of emic standardization when the production is high rate (Roux 2003). It can be suggested that emic standardization extends over a larger area than mechanical standardization, which would be related to the output of a particular workshop or even individual. As such it can help recognize communities of practice. This distinction can also be seen to relate to the difference between ‘style’, which can show emic standardization shared between various production locations, and a ‘ware’ which relates to standardization in terms of clay and temper selection (fabric) and technical choices based on more specific skills and shared on a smaller scale. As such it has consequences in terms of scale and the difference between emic and mechanical standardization will feature again in the discussion on modes of transmission. The fact that archaeological categories might not reflect emic categories of ceramic vessels is important (Gosselain 2008, 175; Miller 1985). In this way, classification of details of rim shapes and morphology are most directly related to the *chaîne opératoire*, and so based on technical decisions made by the potters, which need not always be recognized, or indeed deemed relevant by the consumers if they do not have a direct influence on the function of the vessel (see § 2.3.7).

2.2.11: Efficiency

Efficiency has usually been seen as an important driver of specialisation. Yet, the relationship between production, demand, and technical skills to increase output has recently been called into question in terms of the rationality of ‘efficient’ decisions (Arnold 2008, 10; Costin 2001). Arnold suggests that specialisation itself can cause efficiency to rise and should not be taken as a necessary goal of potters, especially in pre-modern times (Arnold 2008, 318-319). For instance, the adoption of the wheel in the Maya community studied by Arnold happened primarily for social reasons, and only secondarily because of technical advantages (Arnold 2008, 319). Contributions in a recent volume by Glatz offer a similar critique (Glatz 2015a, 18).

It is important that specialisation, especially related to the use of the wheel, can show cyclical movement, where the skill is gained and lost (Franken and London 1995; Laneri 2011; Roux 2008). Skill, forming the last important indication of specialisation, is particularly relevant to the transmission and adoption of ceramic techniques between individuals as it can be a buffer (not having enough skill) or a conductor (between skilful potters).

2.3: Skill

Skill is the most subjective aspect of the organization of production and specialisation, and remains understudied (Costin 1991, 39; Kuijpers *forthcoming*). However, differential levels of skill are crucial to the discussion. Skill is intrinsically linked to experience and experimentation, getting to understand raw materials, such as the workability of the clay, and the use of different forming techniques, decoration and firing (Gosselain 2008, 152-154). Both degree of uniformity and variability can be explained by skill of the individual potter and questions of demand (Underhill 2003). Individual skill is crucial in both horizontal and vertical transmission (see § 3.2 for discussion on vertical vs. horizontal transmission), is acquired through a long learning process, and is something which cannot be readily copied. The amount of skill displayed by potter is also related to his/her success in copying traits from more distant traditions (horizontal transmission), with higher skill leading to more successful copies, especially of more difficult shapes (Gandon *et al.* 2014; Gandon *et al.* 2011). As such, skill plays an important role in the evolution of ceramic vessels. If skill leads to fewer errors, it could lead to more faithful transmission leading to cumulative ‘descent with modification’ from a common ancestor. However, skill is individual, and will vary within a community (not everyone will be equally skilled).

In terms of skills and learning, ethnographers have noted that the sequence in which potters learn skills is not the same sequence as the *chaîne opératoire* (see § 2.3.7) of producing certain vessels (Arnold 2008; Gosselain 2008, 160). According to Lave and Wenger (1991: 96): “Production activity-segments must be learned in different sequences than those in which a production process commonly unfolds, if peripheral, less intense, less complex, less vital tasks are to be learned before more central aspects of practice.” This brings us to the question of skill and age.

2.3.1: Skill, age and gender

Children often start by participating in tasks which require less skill (Arnold 2008, 65-66; Roux and Courty 1989, 10). The incorporation of children in ceramic making has for instance recently been stressed for Middle Bronze Age Cyprus, and plays a role in our case study on Tell el-Yahudiya ware (Gagné 2014). The learning of pottery skills by children is an important component of the idea of descent with modification from a common ancestor, where potters transmit knowledge to a new generation, whilst changes introduced from one generation of potters to the next can lead to changing pottery practices visible in the evolution of ceramics.

Roux for instance cites children participating in the production of ritual vessels (*Divali* lamps in India) due to the high demand and low qualitative standard (Roux and Courty 1989, 11). Evolutionary studies suggest that adult-to-child teaching ('pedagogy') is essential, and imitation on its own is insufficient to account for the transmission of knowledge, in this case pottery making (Tehrani and Riede 2008). The learning curve for children starts with small vessels and this is important. On a general level, the development of wheel-throwing might first be attested in smaller sized vessels of limited morphological complexity (beakers and bowls are thus good candidates). One of the hardest tasks is learning how to form a vessel, in particular using the wheel. It requires many hours of practice, i.e. learning through trial and error (Roux and Courty 1989, 750; 1998). As such we might expect that the use of the wheel would be more inclined to show vertical transmission and be spatially restricted depending on local social conditions.

Particular skill can be shown in decorating vessels. Skill in pottery making can also be compartmentalized, where individuals can either be good in forming vessels, or decorating them. There might be issues of gender as well, for instance in the division of labour. These distinctions are however hard to ascertain in the archaeological record. On the basis of ethnographic records, Arnold (1985, 226) suggests a gender division exists between household potters, being both male and female, and more specialised ceramic production outside of the household, where women are generally no longer involved (workshops) (Arnold 1985, 226). However, gender divisions very much depend on the general social structure of the relevant society. One key aspect where different levels of skill and the development of skill are crucial is the use of the wheel.

2.3.2: Wheel fashioning and wheel-throwing

An important component of specialised production can be attributed to the introduction and the use of the wheel (Glatz 2015a; Roux and Courty 1989). Both using the wheel to finish coil-built vessels and its use to throw a vessel from a lump of clay require significant skills. This sets techniques using the wheel apart from other methods such as coiling and using a mould. The necessary skill increases with the number of different steps involved in forming executed on the wheel (Courty and Roux 1995; Roux and Courty 1989; 1998). Unfortunately, as demonstrated by Roux and Miroschedji (2009), the presence of the fast-wheel can be problematic to recognize on the basis of visible traces on ceramics alone, as similar traces visible to the naked eye can be attributed to the use of a tournette (slow-wheel) and the finishing of coiled built vessels on the wheel.

More often than not, no direct evidence of wheels is preserved, and must be inferred from the ceramics studied. Well known inferences are concentric rilling and string-cut bases, the latter created while removing the vessel from the wheel or hump of clay with a string while still rotating (Doherty 2015, 81: Fig. 6.10; Rice 2005, 129). S-shaped cracks have been stated to be indicative as well (Doherty 2015, 66: Fig. 46; Orton and Hughes 2013, 134; Rye 1981). Yet even for an archaeologist it can be hard to recognize the degree to which the wheel is used (Courty and Roux 1995). Above all, traces such as rilling and string-cut bases can be removed later when re-shaping the vessel, smoothing the surface, or applying a slip.

Tellingly, Doherty, conducting experimental work in an analysis of the wheel in Egyptian ceramic production, finds the distinction between ‘fast’ and ‘slow’ wheel hard to ascertain (Doherty 2015, 91). She was able to produce replica pottery at a slower rotation than usually assumed to be necessary for centrifugal force (Rye 1981, 74: 80-100 rpm; Jacobs and Borowski 1993, 53-55: suggest 50 rpm is enough). However, Doherty claims to be able to introduce centrifugal force at a speed of 20 rpm, considered too low by some to be considered as wheel-throwing (Doherty 2015, 91). One might thus wonder how useful the distinction between the fast and slow wheel is at this point. A better way forward seems to consider the use of the wheel within the specific socio-technical context of interest, and to review what the wheel offered in terms of possibilities and choices to the potter using it in light of the materials in use and the desired vessel form. Another factor which needs to be

accounted for is the size of the vessel being made on the wheel, as most of the vessels discussed by Doherty seem to be of a relatively small size. In order to keep larger vessels from sagging, perhaps a faster wheel and thus a stronger centrifugal force was necessary.

Remains of the wheels themselves are relatively rare in the archaeological record, and often absent (as in the case of 2nd millennium BC south-east Arabia). However, the type of wheel might be inferred from the vessels produced (Orton and Hughes 2013, 130; Roux and Courty 1989, 142-143). As Orton suggests (2013: 130) the character of the wheel will generally reflect the requirement of different vessel types. For instance, the weight and size of the wheel will influence both its momentum and its optimum speed, as heavy wheels will retain their momentum for a longer period but revolve at a slower speed. These heavy wheels resist the friction of the potters hands better than a light wheel does (Orton and Hughes 2013, 130).

To aid the recognition of the use of the wheel, methods using X-radiography and examination of thin-sections have been reported to help in separating between these techniques (Berg 2011; Courty and Roux 1995; Rye 1981). However, the same method can yield different conclusions (Glatz 2015a, 18; Laneri 2011). Usually, with the lack of microscopic or x-ray examination, features such as a spiral rilling visible on the inside of the vessel, and string-cut bases are seen as signs of the use of at least a relatively fast turning wheel (Courty and Roux 1995; Rye 1981). Recently the presence of the wheel and particularly wheel-throwing has been carefully examined in the Levant, Eastern Mediterranean, southeast Iran and southeast Arabia, showing that the assumption that vessels showing wheel-marks were actually thrown is problematic, as they were often coil made and wheel finished (Berg 2009; 2011; 2013; Courty and Roux 1995; Roux and Courty 1998; Méry *et al.* 2010). Valentine Roux and colleagues have provided a particularly robust critique in this case which has contributed to a sharper distinction, as well as the identification of some tools useful in distinguishing between the two techniques with reference to the Chalcolithic and Bronze Age Levant (Courty and Roux 1995; Roux and Courty 1997; Roux 2009; 2015a). It is important to note what difference this change makes in terms of skill and organization of the potter.

The main difference between wheel-finishing and wheel-throwing is that in the latter case the centrifugal force (Rotary Kinetic Energy: RKE) is used to form a vessel from a lump of clay in four distinct phases (centring, hollowing, thinning and forming) (Courty and Roux 1995; Roux and Courty 1989; 1998). The potter is also able to use two hands for a considerable time to form the vessel while rotating, due to the centrifugal force of the rotating wheel (Franken 1969). Wheel-throwing is specialist work and takes many years to learn often starting at a young age (Roux and Courty 1989). In the case of the Udar Pradesh potters' boys started learning to work on the wheel around the age of 8, when their bodies (length of arm, etc.) were developed enough to do the manual work (Roux and Courty 1989). Throwing requires different material as well, with finer textured temper (abrasion of hand) and sufficiently elastic clay (plasticity) (Franken 1969; Rice 2005, 128).

The amount of skill necessary to throw a vessel depends on its size and shape (either open or closed), a number of factors regarding the position of the widest point, and the size of the orifice (Roux and Courty 1989, 140). For instance, smaller vessels with the widest point above the middle of the vessel require less skill than larger vessels (over 30 cm in height) with sharp carinations, or a small orifice which would inhibit the potter to access the base at a later stage of throwing (Laneri 2011; Roux and Courty 1989, 140). It might be suggested that relatively small vessels were easier to throw on the wheel. And it is no coincidence that young apprentices often start by learning these shapes. Larger vessels pose more of a challenge, and would often still be formed with the aid of coils. This has been suggested in Roux's (2005a) examination of Middle Bronze Age vessels in the Levant. Other techniques, such as turning the vessel upside down – placing it on a mould – to finish on the wheel, or even cutting the base and closing it upside down require considerably more skill and cannot be readily assumed. This discussion plays a role in our case-studies, as the presence of the wheel can be inferred, yet the technique of actual wheel-throwing is assumed but might need further corroboration.

2.3.4: The use of the wheel and efficiency

The appropriation of the wheel has traditionally been used as an argument for increasing efficiency and speed of production, yet this assumption was recently contested (Glatz 2015a). Some techniques are only efficient when used at certain level

of specialisation and this can even be a reason for rejection of the wheel (Arnold *et al.* 2008).

In principle, the production of coil-built but wheel-finished vessels does not significantly increase speed. Moreover, the assumption of the use of a fast wheel needs to be conservative, as experiments with known types of wheels and examination of vessels suggest that oftentimes the wheel was used to finish coil-made vessels. The kick-wheel seems to have been a fairly late invention (Roux 2015a). Simpler pivoted wheels (often made of basalt in the Levant) had a lower rate of rotation (Roux 2009; 2015a).

With the use of these wheels in the Middle Bronze Age Levant, fairly small vessels could be thrown off the hump, whereas larger vessels could not be thrown because of the lack of centrifugal force (Glatz 2015a; Roux 2015a). It is this capacity to throw smaller vessels off the hump that seems instrumental in some important evolutionary changes within the case-studies examined in the current thesis.

2.3.5: The agency of the wheel

In terms of agency, one could argue that there exists a dialectical relationship between the tool (wheel), the clay and the person throwing a vessel (Laneri 2011; Malafouris 2008). Following this discussion of specialisation and the use of the wheel, it is now time to introduce a fundamental concept to the study of evolution in the sense of ‘descent with modification from a common ancestor’, namely the *chaîne opératoire*.

2.3.6: The *chaîne opératoire*

The study of the *chaîne opératoire* (operational sequence) or chain of production of an artefact has long been an important methodological framework in archaeology and anthropology (Schlanger 2005). As such it has been an important component in the study of material culture in the Near East (in the Levant, and less so in SE Arabia) as for instance exemplified in a recent volume on the topic (Franken 1969; Méry *et al.* 2010; Rosen and Roux 2009; Roux *in press*). Ina Berg (2011: 57) defines three levels in the *chaîne opératoire*, these being the ‘operational sequence’ the culture process (based on choices and beliefs) and the sensual aspect between material, object and maker. The latter two levels have particular relevance for our discussion of selective pressure and agency. In terms of the *chaîne opératoire* as the ‘operational sequence’ it

is the fundamental principle through which descent with modification takes effect, and the ideal level at which to study evolutionary patterns of ceramic change through time.

2.3.7: *Chaîne opératoire* and a conceptual basis for descent with modification

The concept of the *chaîne opératoire* has proven very useful for our perception of ancient ceramic production as it approaches production by looking at the sequence of steps taken by a potter, from the selection of the clay and temper, the preparation of the clay, to the forming of a vessel, subsequent firing and treatment after firing. Particularly relevant is that the *chaîne opératoire* is socially transmitted between individuals or within a restricted group; for instance within a pottery workshop. Hence, in terms of the Darwinian principle of ‘descent with modification from a common ancestor’ one can see it as the fundamental level of social transmission of knowledge of making pottery in a particular way (a certain tradition). A similar stance has been put forth in evolutionary studies as emphasized by Tehrani and Riede (2008). Change occurs through the (social) selection of variation while handling the clay and technical variety in making the artefact. It is thus possible to see this production chain as a material cultural parallel of the genotype, inherited and transmitted within a population. In this way, the social aspect of the interaction between potters (and their individual perception) is essential, as it is through social actions that this information on producing an artefact is transmitted. Through time, variations might be introduced in certain links of the production chain, either through individual experimentation, copying of certain practices, or initial ‘mistakes’. Selective pressure might show a preference for a certain type of variation, due to social, political or environmental reasons, such as changes in the availability of raw materials. However, these are always mitigated in social terms through the practice of the potter. Hence, selection of variation is always played out on the social level; i.e. the selective pressure causing mutations to be accepted or discarded is always translated into social factors. This is stressed by Dean Arnold in a recent volume on ceramic production in a Maya community, where he states that: “Human choices thus have multiple layers of complexity. What vary, however, are the constraints for those choices, which may be environmental, social, political or technological.” (Arnold 2008, 13). This premise is particularly relevant in combination with the *Annales* approach with its focus on different temporal scales, as the above mentioned factors

can be said to relate to just such multiple time-scales (Braudel 1972; Fletcher 1992). In other words, although environmental factors play an important role and add selective pressure, such as the availability of certain clay sources, or sparseness of water needed when preparing the clay or fuel for firing, these environmental conditions work into socially transmitted choices by the potter (Arnold 2008; Roux and Rosen 2009, 12).

A challenge for archaeologists adopting an approach influenced by the concept of the *chaîne opératoire* remains the visibility of these different steps. For ceramic production, traces of the steps in production undertaken in the early stages of making a vessel can easily be obscured by later actions, and multiple action sequences may give the same result.

An essential difference remains because material culture itself does not carry the *chaîne opératoire* as a living being would carry its genetic code in its DNA (if only pots had DNA!). A similar stance has been put forth in evolutionary studies by Tehrani and Riede (2008). Whereas genetic information has proven essential in entangling the details of evolution in biological species, this is not as readily possible for artefacts. The production chain itself is inherited not through direct reproduction of artefacts, but in the minds and social actions of humans making these artefacts. It is thus non-material (except perhaps when written out as a set of instructions) and transmitted between individuals, leaving only the material remains. Thus, as archaeologists we are left with the material result, from which we try to unravel the socially transmitted action. This difference is reminiscent of the distinction between a *phenotype* and a *genotype*, where a phenotype shows the ‘properties of an organism created by the *genotype* interacting with the environment’ (O'Brien and Lyman 2003, 238). However, similar phenotypes do not have to share the same genetic code. In this regard, the *chaîne opératoire* represents a technological equivalent of the *genotype* of an artefact, representing the encoded actions that are socially transmitted and relate to environmental constraints. However, in the case of past actions these have to be hypothesized from the phenotype, the actual artefact - the material result. However, similarity in outward appearance, say two identical juglets (see chapter 4), does not have to represent the same *genotype* but might be due to other processes such as the copying of visible traits (only parts of the production chain) or to similar parallel developments (in cases where a similar production chain developed independently).

Thus, in cultural terms, we can have two very similar artefacts that are the result of very different production steps. For ceramics, a typological comparison is often done on the basis of these visible characters, and hence apparent comparability between two phenotypes does not necessarily imply a similar underlying production chain (see also Roux and Rosen 2009, 13).

2.3.8: The *chaîne opératoire* and selective pressure

The individual steps within the *chaîne opératoire* are susceptible to change (mutations), either dependent or independently of each other. These mutations can have selective advantages. A core argument of this thesis is that this selection is extensively shaped by the interaction of the potter with his/her social, economic and natural environments.

2.4: Stylistic variation and the role of decoration

2.4.1: Drifting Decoration? Style and function: a false dichotomy

A dichotomy has been drawn between ‘style’ and ‘function’ in evolutionary archaeology (Dunnell 1978; 1980; Shennan and Wilkinson 2001; Bentley 2011). This dichotomy is drawn on the basis of a difference relating to selective pressure. As defined by Shennan and Wilkinson (2001: 578): “variation is defined as functional if it may be accounted for in terms of selection and stylistic if it is not under selection.” However, others have argued that motifs (decoration) can be subject to cultural evolution (Glatz 2015a; Richardson and Boyd 1995).

The problems of this limited definition of ‘style’ have already been addressed by Shennan and Wilkinson (2001, 579), who suggest this lack of a clear-cut distinction in the different meaning of ‘style’ does not help the acceptance of these quantifying methods in a broader archaeological community. It has been argued that style drifts, thus shows random variations, which can be picked up by seriation methods, but does not relate to processes of descent with modification from a common ancestor (Neiman 1995).

The style versus function dichotomy is inherently problematic and will be questioned in this thesis (Hegmon 1998; Wobst 2004; Hegmon and Kulow 2005). For instance, the style of decorating certain vessels might not make a direct functional contribution to the vessels’ performance as a medium for storing, serving or

consuming a commodity, however, the decoration itself might have particular cultural significance to the consumers acquiring the vessels, and hence be more desirable, translating into social selective pressure for the potter manufacturing the vessels. As such, style is selected and relevant to discussions on communities of practice and even questions of cultural belonging and ethnicity. Yet the question of ‘who interacts with whom and learns from whom’ is directly relevant to the creation of cultural groups and feeds into questions of communality of cultural practice and identity. Accordingly, stylistic features might show different patterns of transmission, either being inherited within a small community, or adopted from outside influences in design. Precise time-resolution would be needed to test models of micro-evolution and the role of neutral vs. directed varieties. Nevertheless, Shennan suggests that one of the key reasons to consider whether variation through time is neutral or ‘directed’ is because we need to identify the presence of selection or bias which pushes people (potters) to make decisions with a ‘consistent direction over time’, and for us to attempt them in such a way (Shennan 2011, 1078). Following this line of argument, Shennan and Wilkinson argue that (2001: 578): “Stylistic features will increase and decrease stochastically in relative frequency while traits that are under selection will increase in frequency until they are fixed.” Concluding, Shennan and Wilkinson suggest that (2001: 590) we need to be particularly careful about making *a priori* assumptions about the kinds of cultural attributes (decoration, a vessel rim) that are under selection, and should use the appropriate methodologies to establish these assumptions.

Two important issues suggest that the assumption that decoration would not be prone to processes of cultural evolution is false. Firstly, style can have a selective advantage which is socially mediated. As mentioned above, style plays an important role in the communication of identity by individuals, within groups, and between groups. The decoration on ceramic vessels and stylistic changes can thus have selective advantages mediated through the potters. Secondly and importantly, style, and decoration of pottery, has a technical basis, just like the forming of a vessel. Hence, decoration is dependent on the material to be used, the skill of the potter and the appreciation of the decoration, and thus has the potential to be subject to processes of descent with modification within the *chaîne opératoire*, just like any other step in the production process. However, there might be important differences in the type of

way decoration is transmitted (learned or copied) as opposed to the forming of vessels. This can largely be related to the visibility, which we will discuss further below (§2.4.4).

2.4.2: Style, decoration and social interactions

The role of style and decoration in social interactions and the creation of social boundaries has formed an important research agenda in ceramic studies (Hegmon 1995; 1998; Plog 1980; Stark 2003). For instance, Hegmon (1995) uses the study of the structure of design on the ceramics of small-scale societies in the American Southwest dating to the ninth century AD, to compare rules of design (lay-out, use of particular motifs) and analyse what role they play in creating social cohesion on different levels. She draws important conclusions on the different roles of design, which are of value to the present thesis.

Style is mostly equated with design (Hegmon 1995, 7). However, it should be defined more generally as a way of forming a vessel and decorating it with designs (Hegmon 1995, with adjustments). Hence, style is a more inclusive term for a group of ceramics than defined by a particular *chaîne opératoire*, as multiple ways of producing a vessel can generate vessels with a similar (superficially equal) style.

Plog (1980) has argued several decades ago that ceramic design variation is influenced by exchange, temporal variation and stylistic differences between different vessel forms. These factors are all driving ceramic evolution. Moreover, Plog adds that it is important to take settlement-subsistence systems into account when explaining stylistic variation.

The role of ceramic decoration in social boundaries is stressed in a relatively recent volume (Stark 1998). Costin and Hagstrum, in a study of a variety of pre-Hispanic ceramic types, conclude that the degree of labour investment varies according to the social and political functions of the vessels (Costin and Hagstrum 1995, 635). However, as Hegmon concludes, ceramic decoration can fulfil different roles, either stressing differences within social groups, or signalling group coherence (Hegmon 1995). In this regard, Hegmon stresses the agency of painting decoration on pottery (Hegmon and Kulow 2005). Spielmann argues that highly decorated objects with significant social roles, for instance in rituals or feasts, can drive specialisation (Spielmann 2002). However, an important and repeating feature is the decline of

decoration within ceramic traditions or styles, as for instance discussed by David Wengrow as the ‘evolution of simplicity’ (Wengrow 2001). This has to be explained and forms a key component of the patterns of descent with modification within ceramic evolution. Franken and London also comment on the complicated relationship between material, techniques and social changes which lead to the loss of painted ceramic styles at the end of the Late Bronze Age in the southern Levant (Franken and London 1995).

2.4.3: Learning and innovation and units of analysis

Which is the appropriate level at which to study transmission of knowledge relating to ceramic manufacture? Arnold suggests that the basic unit of analysis should be the household unit (Arnold 2008). This definition can extend to a workshop setting where potters are working together and new potters are introduced to pottery-making. The appropriate level can be inferred from level of specialisation (see above).

In a recent article, Roux stresses the transmission systems of wheel-fashioning in the Southern Levant (Roux 2008). She suggests a link between the availability of knowledge and the robustness of the technique through time. Following her argument, the use of the wheel was a rather isolated technique known by specialists working for ‘elites’ during the Chalcolithic, developing into a closed but stable system linked to larger habitation centres in the Early Bronze Age, and only into a robust system within the 2nd millennium BC (**Fig. 2.1**). The model offers an explanation for why innovations, such as the use of the wheel, can disappear again, unless they are shared by a sufficiently large number of people; in this case, potters. This model is important when we consider the agency of transmission (§2.5).

2.4.4: Modes of transmission within ceramic production

In evolutionary theory, three distinct modes of transmission are usually discussed, described in in relative relation to transmission through time (generations) and (as we will argue) geographical space: *vertical*, *diagonal* and *horizontal* transmission (See § 3.2 for more detail). Arnold has stressed the level of the household in the transmission of ceramic craft (2008: 49): “Transmission of the craft from generation to generation thus tended to coincide with the same factors that define, create, and perpetuate household composition.” This is also the approach I take in this thesis.

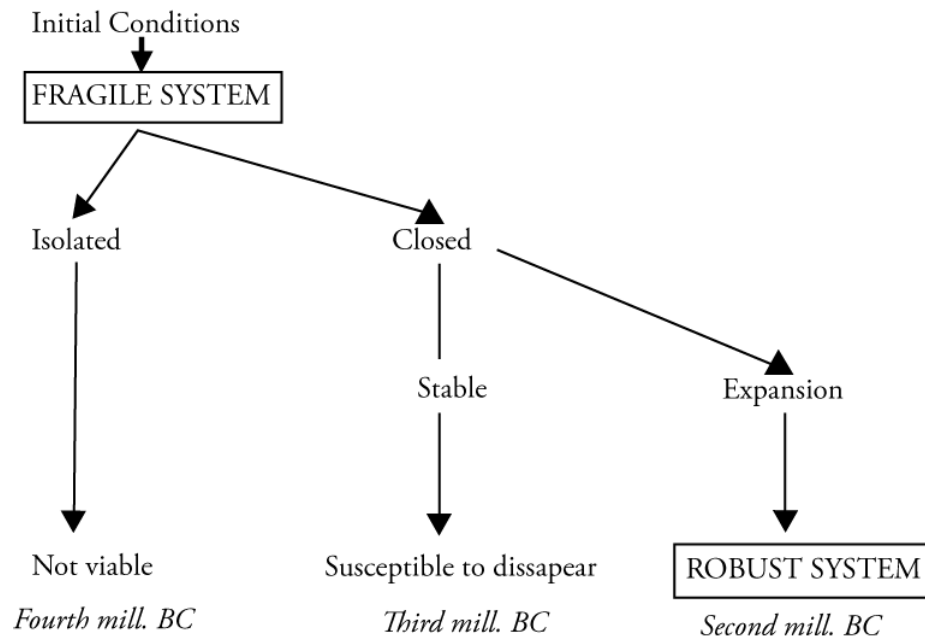


Fig. 2.1: Scheme of the change from a fragile system to a robust system of ceramic technology, based on the fact that the context in which the technique is practiced moves from isolated, through stable to an expanding situation (Redrawn after: Roux 2008, 100: Fig. 5.4).

We as archaeologists often do not possess the level of detail necessary to address transmission between individuals, which needs particularly detailed contextual information of a kind that is exceptional in the ceramic record. Nevertheless, this transmission is essential to transmission *within* the household. As units of analysis, the workshop or household can be taken as an unknown number of individuals operating under similar conditions, exchanging experience between them, and bringing in experience from outside of the immediate local surroundings. As such, this unit of production is influenced both by processes of vertical and horizontal transmission. This hierarchical relation is summarized in **Fig. 2.2**.

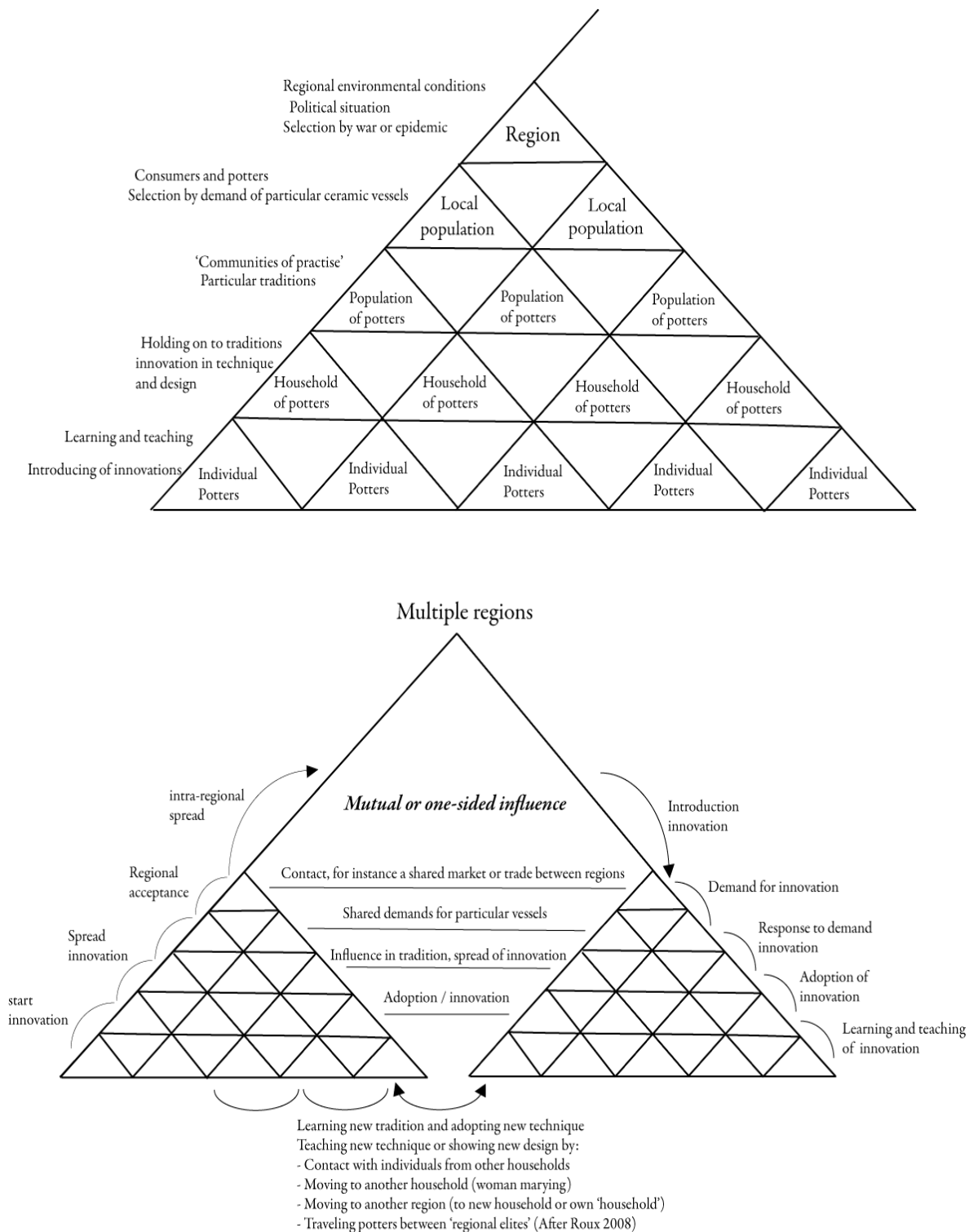


Fig. 2.2: : The scale of transmission can be seen as hierarchical, from individual potters within a household setting, to the regional scale and transmission between regions (After ideas adopted from Roux 2008; Arnold 2008).

2.4.5: Environmental constraints

We have thus far overlooked environmental and technical constraints on pottery-making, yet the limits and possibilities set by the environment and material are crucial to understanding ceramic evolution. This agenda has been most strongly advocated by Dean Arnold in a number of publications, falling under his approach of ‘ceramic ecology’ (Arnold 1976; 1985; 1993; 2008). Arnold (1985:2) sees it as central to understand the ‘relationship of craft to the environment on the one hand and to culture on the other.’ This relation is analysed on the level of the potter community (Arnold 1985, 17; Arnold 2008).

For our case-studies, this is of major importance. For instance the connection with aridification connected to the 4.2K Event and seen by some as instrumental in precipitating the changes at the start of the 2nd millennium BC in Southeast Arabia, and might play a role in shifting pottery practices due to changing access to water sources, fuel and clay (see Chapter 6). However, as cultural adaption to environmental change is socially mediated, the same is applicable to changes in ceramic practices (Arnold 2008). Moreover, not all aspects of ceramic production need to be linked to environmental factors in the same causal way, as we may envisage particular stages of ceramic production, such as clay procurement, provision of water for levigation, or firing which is dependent on sufficient fuel, as being more strongly regulated by environmental constraints, than others.

Fortunately, Arnold has recently adopted just such an approach and brought together years of ethnographic experience to form a synthesis of the evolution of a Maya community of potters (Arnold 2008). Here he presents ideas on the hierarchical importance of selective pressure on different stages of ceramic production, and the levels of conservatism within different stages of ceramic production. His conclusions are particularly relevant for our own evolutionary approach, though it must be said that Arnold works from a social evolutionary perspective, whereas my approach is more strongly based on Darwinian principles of descent with modification. Nevertheless, the two approaches are interlinked. In Arnold’s analysis change in ceramic production is divided into a number of connected but separately analysed stages, such as the change in population and organization of production, demand and consumption, distribution, clay procurement, temper procurement, composition of fabrics, forming technology and firing technology. Importantly, these different stages

of production have different relations to selective pressure which may be predominantly social, economic, political or environmental.

2.4.6: The conservative nature of ceramic production

As indicated, Arnold (2008) has examined the relationship between pottery and social change in detail and pleads for a hierarchical relationship in terms of conservatism, to change in pottery practices relating to material and environmental conditions. These relationships are important and can form conditions which inhibit change in ceramic practices, thus becoming conditions which can regulate evolutionary processes (in evolutionary terms these might be called Transmission Isolating Mechanisms or 'TRIMS' (see §3.3).

The conclusions drawn by Arnold are highly relevant for us. He shows, on the basis of his ethnographic studies among Maya potters, that the nature of consumption (demand), vessel shapes and patterns of distribution change relatively easily (Arnold 2008, 312). On the other hand, the community of potters, the paste, and technology of production change more slowly (Arnold 2008, 312). Arnold specifically argues that the conservative nature and stability of the household unit makes this a particularly appropriate unit of analysis for ceramic evolution (Arnold 2008-318).

In terms of evolutionary studies of material culture and our case-studies relating to decorated ceramic vessels, it is highly significant that Arnold (2008: 312-313) shows that within technological changes, decoration was most flexible and likely to change, being subject to changing demand, followed by changes in shape (Arnold 2008, 312-313). This principle will be explored further below. Sources of paste and temper did not seem to change unless they were exhausted or overexploited (Arnold 2008, 313). We can add to this that migration, or movement to a new area, can change the procurement of clay and temper. In terms of material conservatism, clay is usually procured close-by, within a radius of between 1 km and 6-9 km (Arnold 1985, 232), while temper can be procured from greater distances or even imported from other regions. Clay recipes can change as well due to technical demands, such as the need for more plastic clays for wheel-throwing. Alternatively, they can influence techniques, as lean clays with many mineral inclusions are unsuitable for wheel-throwing (Franken 1969; Franken and London 1995). These factors come into play when regarding environmental stress on clay and water procurement, and the need of

good quality clay to produce vessels on the wheel. These dynamics will be discussed again when considering Wadi Suq ceramic vessels (Chapter 5-6). In Arnold's case study, firing technology changed due to changes in kiln techniques and changing access to firewood (Arnold 2008, 313). However, clay and temper can also dictate firing regimes and changes in firing atmosphere (oxidizing, reduced). For example, over-firing of lime-rich clay can result in lime-spalling (Rice 2005, 98). Moreover, particular firing regimes can be part of a style, for instance the firing of iron-rich clays under oxidizing conditions to obtain a bright red colour, or a dark hue (black or grey) when using a reducing atmosphere. In this way, they will also influence change in decoration. Changes in the use of clay and temper are fairly conservative (Arnold 2008). As such they can give a geographical location for a particular ceramic practice. Having detailed knowledge of these factors can pinpoint the *chaîne opératoire* to a certain location. Importantly, knowledge of clay is also socially transmitted; such as the workability and location of clay beds, and is imbued with social meaning (see Arnold 2008). As such, clay processing forms a local and often personal adaptation to social and environmental demands (Gosselain 2008, 161-164). It is crucial to stress that environmental, economic, and political selection is socially mitigated. This is why in reality it is hard to boil change down to a single cause, as it will be social actions mitigated by various additional factors which drive change in potters' behaviour.

2.4.7: Seasonality

Seasonality is often understudied in the ceramic record. Ceramic production can be seasonal for various reasons, including the availability of water (rainfall), temperature, and agricultural schedules (Arnold 1985; Costin 1991). Seasonality plays an important role in the distinction between full-time and part time potters and specialisation. As such it forms a particularly relevant topic in the discussion on specialisation within south-east Arabia, where communities likely had to adapt to seasonal rhythms of agricultural and water availability, alternating between agriculture and making pottery (Méry 2013). Seasonality can also feature in terms of the intensified demand for ceramic vessels, as this might be related to seasonal meetings and migrations, funerary rites and festivities, especially in regions where environmental conditions dictate seasonal activity. These dynamics play a role in both

the production of Tell el-Yahudiya juglets and Wadi Suq vessels used in funerary rites (see case-studies).

2.4.8: Gender divisions

Usually a gender division is assumed in terms of specialisation (at least in terms of location). On the level of household industry: “Females may be potters in this system state because of their ties to the household, but men may also be potters or assist women depending on the yearly climatic pattern and if the optimum weather for pottery production does not conflict with significant male subsistence patterns” (Arnold 1985, 226). Pottery production is part-time due to a woman’s household responsibilities and because the weather (rainfall) necessary for subsistence (such as agriculture) may provide regulatory feedback for the craft. If potters are male and have some agricultural land, however, agriculture would retard an increased intensity of the craft, since pottery making would have to be interrupted to perform agricultural tasks.” (Arnold 1985, 226). Although it is important to be cautious of gender divisions, these will remain hypothetical when dealing with archaeological case-studies.

2.4.9: Differences in transmission of ceramic character traits: visibility and malleability

One of the main goals of this chapter is to see if we can establish whether there might be different rules affecting the various aspects of ceramic production, which impact upon divergent arenas such as transmission, geographical scale and their relation to different selective pressures (environmental, social-political, economic). One particular hypothesis is that visible ceramic traits are easier to copy than less visible traits by people outside of a particular production system (see Gosselain, in particular 2008). In practice this means that highly visible characteristics of ceramic vessels, such as particular painted motifs (or surface treatments) can transfer over wide areas and be copied by potters working in different traditions. This has consequences for our archaeological definitions of what we call a ‘style’, ‘ware’ or ceramic ‘horizon’ (I will return to these definitions in the discussion: chapter 7).

However, in a later article, Gosselain (2008: 170) warns against the perception of a “closed technical unit”. Here Gosselain states that they are as likely to be altered or merged as more open technical systems. However, this statement was made on the basis of techniques such as pounding and moulding, not on the use of the wheel,

which introduces boundaries in terms of skill. Shaping techniques are thus prone to borrowing and blending as well, and it becomes a question of degrees of copying of a particular technique.

Gosselain argues that not all decorative motifs will be easily copied because of cultural boundaries (2008: 173): “Thus, aesthetic and economic motivations alone are not enough to generate borrowing or innovation at the level of decorative practices. Because decorative style may be interpreted locally as highly emblematic of specific groups”. These groups can be defined in familial, factional, ethnic, linguistic, or regional terms (David and Kramer 2001; Gosselain 2008; Stark 2003, 204-205). Nevertheless, not every decorative motif is an expression of a particular group, but can be related to particular functions or occasions. In a number of recent articles, Olivier Gosselain (1992; 1998; 2000; 2008) has focused on the various modes of transmission of ceramic traits that might relate to the expression of identity and ethnic affiliation in Africa, and has stressed the visibility of the characters, and the techniques used to create these decorative traits (Gosselain 1992; 1998; 2000; 2008). Although his case-studies revolve around handmade vessels within traditions of household production, the idea of difference in transmission relating to the visibility of characters is very important for our case-studies and the study of ceramic evolution in general. Gosselain sees pottery industries as ‘sociotechnical aggregates’ that form an ‘intricate mix of inventions, borrowed elements, and manipulations that display an amazing propensity to redefinition by individuals and local groups’ (Gosselain 2000, 190). He suggests (Gosselain 2000, 191) that it is valuable to take into account the context in which ceramics are produced and the visibility and ease of copying various stages in the production process, and argues for two dominant factors in the difference of transmission of ceramic traits:

1. The visibility of the trait
2. Its technical malleability (Gosselain 2000, 191).

These features relate to the ease of copying and the way the traits can be transmitted in space and time: highly visible and highly malleable features would have a tendency to be transmitted horizontally and across a large spatial extent (Gosselain 2000, 191-193). For instance, highly recognizable decorative patterns,

needing limited skill to copy, would transmit with ease outside of the local production unit. They are thus easily borrowed and imitated by observation alone, rather than through the form of an apprenticeship, guidance or extensive teaching (Gosselain 2008, 172). This principle is particularly relevant to our archaeological definitions of decorated ceramic styles (or ‘wares’) such as Tell el-Yahudiya ware. The surface treatment of reduced firing, polished surface and incised decoration filled in with lime is easily recognizable (hence its separate treatment by archaeologists), yet also fairly easy to copy by potters familiar with these basic techniques, thus leading to copying of this way of decoration by different communities over a wide area (see chapter 4 for more detail). The same could be said for a clearly recognized technical feature such as a particular type of spout, which could be reproduced with relative ease and copied by other pottery producing communities. However, a specific clay source or temper would be harder to copy without having more detailed knowledge (think of the initial difficulty of copying Chinese porcelain in Europe), as well as techniques which would be harder to learn (specifically related to the wheel, see above).

Recently, Roux has offered insight into processes of transmission involving the adoption of a type of white water storage jar (known as ‘Mokalsar’) in India that involves different types of transmission (Roux 2015b). She also distinguishes between indirect transmission, through the copying of visible traits of the vessel (but not always successful) and direct transmission of knowledge *via* verbal communication (between potters, traders and shopkeepers) and technical guidance. In terms of transmission, form could be seen as horizontally directed, the verbal transmission as diagonal, and the technical guidance as vertically oriented. She flags the same issues as important in copying ceramic traits, namely visibility and reproducibility (Roux 2015b, 6), concluding that morphological characters are visible and can be copied. Clay recipe (salt clay, granite temper) can be transmitted verbally and experimented with by a new group of potters. Following these authors, these principles can perhaps be summarized in the table below.

Technique	Manufacturing stage	Visibility	Technical malleability	Spatial constrictions	Vertical Transmission	Horizontal Transmission
Applying decoration	Post-forming	High	High	Low	High	High
Firing	Post-forming	Medium	Medium	Low	Medium	High
Creating vessel shape	Forming	Low	Low	High	High	Low
Rim	Forming	High	Medium	Low	High	Medium
Handle	Forming	High	Medium	Low	High	Medium
Spout	Forming	High	Medium	Low	High	High
Base	Forming	High	Medium	Low	High	Medium
Clay tempering	Pre-forming	Medium	Medium	Medium	High	Medium
Clay procurement	Pre-forming	Low	Low	High	High	Low

Table 2.1: The visibility and malleability of ceramic techniques and the way they might be transmitted.

It still remains to be answered how we define this visibility and malleability? Is it defined on the visibility to the user of the vessel, or a potter acquiring it? What is the role of skill in recognizing technological steps in a certain object? One can imagine a skilled potter being able to recognize more technical traits by visual inspection, than a less-skilled producer, and to know better how to replicate them (as in reproductive experiments done by Loe Jacobs in Leiden, see chapter 4). These questions touch upon a qualitative difference and as such there is one topic which needs further elaboration. This brings us to the question of agency.

2.5: Agency and Materiality

2.5.1: Agency of object vs. Agency of person

The idea of agency plays an important role in the transmission of ceramic knowledge. I choose to focus on the difference of agency between persons on the one hand, and agency mediated through objects on the other hand. Following this distinction, I will argue that the latter type of agency has been slightly neglected as an explicit framework for knowledge transmission in evolutionary theories on cultural

transmission (however, see: Roux 2015b; Smith 2013; Mesoudi 2011, 227, note 2). The distinction is however clearly made in a recent thesis on cultural hybridization, where Burke makes the distinction between hybridization based on the transmission of artefacts, practices or people (Burke 2009). Here we define object agency in the simplest way as the “causal consequences objects (artefacts, architecture, and landscape features) have on the course of human activity.” (Brown and Walker 2008, 289). This theme has featured dominantly in recent archaeological theory on ‘materiality’ (Demarraais *et al.* 2004; Meskell 2005; Steel 2013). Agency also has an analytical function in the study of material cultural evolution. Nevertheless, the approach taken in this thesis differs from that taken by, for instance, Stephen Shennan (2004) who discusses agency and evolutionary approaches through the notion of dual inheritance theory; in the form of genetic and cultural inheritance, focussing on agency in individual human decision making and general population dynamics.

The way agency of objects (instead of person to person interaction) is used in this thesis is to regard their shifting role in social actions, and to *qualify* different ways of knowledge transmission through these artefacts. Hence, it is more in line with recent approaches in materiality. The main focus will however lie on the transmission of *technical* skills depending on the type of contact between producer, object, and recipient. As such it will be less focussed on the phenomenological and epistemological issues of agency, or upon delving into questions of experience on the personal level (Dobres 2000; Gardner 2004), than on the agency of technical actions and how this can shift from object to person. Nor do I believe that using agency in archaeological thinking should steer away from an explanatory objective, with a sense of parsimony. Often, terms such as ‘agency’, ‘hybridization’ and ‘entanglement’ have the potential to be used by archaeologists to throw an intellectual blanket over observable phenomena in order to make it sound novel, in a constant drive to find a new approach (for a similar critique, see: Dobres and Robb 2000, 3-4). By doing so, new terms can obscure rather than explain phenomena by making them less accessible through the use of specialist rhetoric. I realise that the same critique can be voiced for evolutionary approaches in general and the line taken in this thesis. However, as a defence I would argue that an evolutionary approach is used to make assumptions more specific, and offers quantifiable methods to address ideas on cultural

transmission. Moreover, evolutionary terminology has a long history of being used implicitly in archaeological studies, so is in itself not a novelty (Riede 2010).

In this way, agency is used here as an analytical tool to allow for the important fact that not only living individuals can transfer knowledge, but that ‘inanimate’ objects; artefacts, such as ceramic vessels or any other kind of artefact can also actively transmit different levels of knowledge. This stance is far from new in itself. It has been discussed in regard to art and animism, and is an integral part of archaeological theory (Brown and Walker 2008; Dobres 2000; Gell 1998). Moreover, a recent volume edited by Knappett and Malafouris (2008) collects contributions arguing the importance of non-human agency.

However, for the purposes of this thesis I am particularly concerned with the conditions of technical knowledge which are contained in an object, such as a ceramic vessel. Without wishing to reduce agency merely to its technical component, which is only a particular type of agency that an object will hold, I believe this technical component is still underrepresented in studies on the agency of artefacts and most importantly, does not feature explicitly enough in evolutionary theories on the transmission of culture. It does however relate to discussions on copying and hybridization (Burke 2009). Agency has been connected with the technical act of pottery making itself (and skill), with painting decoration, and with the relationship between the potter and the wheel (Gosselain 2008; Hegmon and Kulow 2005; Malafouris 2008). In a recent volume on the Eastern Mediterranean Bronze Age, it plays a large role in the discussion of materiality and consumption (Steel 2013).

Obviously, the aspect of technological transmission changes when mediated through an object, instead of personal contact. The degree in which technical knowledge is read into an object is dependent on at least two important factors: firstly, the visible technical features of the object, secondly, on the capability of the observer to understand these features and relate them to technical actions. A shift can be perceived from objects having an *extrinsic* agency, where the external features and associated contents can influence local perceptions and are transmitted and reinterpreted, to intrinsic *technical* agency which focusses on the comprehension of the technology that went into making the object.⁴ At first, the object’s ‘otherness’ is a

key feature and can be linked to giving it a particular importance, for instance in ritual or elite display (Helms 1988; Appadurai 1986a; Steel 2013). However, along with this, the object can have an agency in inspiring local artisans to produce a similar object.

Along these lines, Alfred Gell's discussion about agency and *index* are useful, in spite of the different context in which Gell uses these terms (Gell 1998).⁵ An artefact can form an extension of the maker or receiver's agency, this extension of agency is the index (Gell 1998, 451; Layton 2003). In his work, Gell uses these terms to discuss the dialectical relationship between artists, objects (art) and observers. However, he does not particularly focus on the transmission of technical actions through objects. I would like to place the discussion of agency into a framework of craftsmen (most specifically potters), artefacts (ceramic vessels) and consumers of these artefacts, possessing different technological knowledge. Dobres also uses the *chaîne opératoire* to connect "tangible and intangible aspects of ancient embodied technological practice" (Dobres 2000, 155). It is precisely this concept which I seek to use in this thesis. However, Dobres focusses on the agency of the technological act, whereas the present focus lays on the technical agency transmitted by artefacts themselves. As Layton has suggested, Gell does not explain the distinctive way in which an (art) object extends the maker's or user's agency (Layton 2003). This is attempted here in an evolutionary framework. In evolutionary terms, the technical agency of an object could be classified as horizontal transmission. However, this can lead to qualitative differences in results based on the success of the recipient to copy the original *chaîne opératoire*.

As said, the different degrees of technical agency possessed by an object are intrinsically linked to, 1) visibility of these traits, 2) the skill involved in reproducing them and 3) the skill set of the person interpreting the object. Nevertheless, the technical agency of objects in their new context depends on local factors. Most important is the skill of the receiver and this person's ability and knowledge of ceramic fabrication, which must be sufficient enough to read technical information into the observed object (both visual, tactile). The potter's interpretation will be based

⁵ I choose not to use Gell's terms of 'patient' for recipient, neither of 'abduction' for the appropriation of an object (Gell 1998) as I feel these have linguistic connotations related to unequal power relations, or even victimisation, which I believe should not be defined *a priori* but depend very much on the context.

on local *chaîne opératoire* and technical traditions. Secondly, as explored above, it depends on the visibility of technical features, which might be obscured. Thirdly, it depends on the general technical level within the recipient environment.

It can be argued that the agency of objects has aspects which clearly distinguish it from agency between persons, and thus has important implications for our models of cultural transmission between populations. For one, objects have the potential to transmit technical knowledge over large geographical distances. Secondly, and equally important for archaeologists (though not often explored), is the ability to transmit technical knowledge through extended periods of time. Objects, such as pots, can be stored (as heirlooms) or retrieved (even excavated) and have agency for potters within the same generation of production, or across generations separated by considerable stretches of time.

2.5.2: Do pots live and procreate?

A final question relating both to the evolutionary perspective and recent studies in materiality and agency is how far we should take the concept of objects as separate ‘actors’ and ascribe them their own ‘life’ (Gosden 2005; Thomas 2015). A recent paper by Thomas (2015) entitled “the future of archaeological theory” summarizes these theoretical viewpoints on materiality, yet strikingly omits to mention evolutionary approaches (an argument for the present thesis in its own right). For instance, Thomas (2015: 1289) states: “For objects do not have to rely on people to animate them; they have the potential to do things independently.” It is interesting that evolutionary approaches are not mentioned in his view of the ‘future’ as without being acknowledged, post-processual theory on objects and materiality actually closely approaches (processual) evolutionary approaches and a gene-centred interpretation of objects as ‘memes’ and ‘extended phenotypes’ influencing human evolution outside of the direct biological organism, as developed first by Richard Dawkins (Dawkins 1983; 2006).

Nevertheless, as interesting or intellectually stimulating as this viewpoint might be, the central stance in this thesis remains pragmatic in stating that material cultural evolution is founded upon human actions, and ceramic evolution needs to be fundamentally understood through its relationship with human actions and perception. Thus, ceramics evolves fundamentally through changes in the *chaîne opératoire* being

practiced by potters. An example might perhaps suffice. An ancient potter in Egypt (the Late Naqada period) could imagine a walking bowl with feet and actually create the striking example shown here (**Fig. 2.3**). This bowl in itself can even stimulate another potter to make a similar object. However, did this bowl ever set off on its own accord at night to find another bowl with which to procreate and start a lineage? This only happens within the confines of the human mind.



Fig. 2.3: This footed bowl from the Late Naqada (3750-3350 BC) stimulates us to think it has its agency and can walk off at any moment (Used with permission of the Metropolitan: “Footed Bowl [Egyptian]” (10.176.113) in *Heilbrunn Timeline of Art History*. New York; The Metropolitan Museum of Art, 2000-.<http://www.metmuseum.org/toah/works-of-art/10.176.113> (August 2009).

2.6: A synopsis: an integrative approach to the evolution of ceramic production

On the basis of the above discussion, is it possible to set out a number of hypotheses and predictions on the nature of transmission relating to different aspects of ancient ceramic production. These can subsequently be tested using evolutionary analysis, which we will discuss in the more detail in the following chapter.

Specialisation: Production integrity higher with more specialisation

The increasing consistency of production due to specialisation, from a household to workshop setting, can increase a phylogenetic signal, particularly on a regional scale. This is perhaps in contrast to expectations of vertical transmission within small scale, relatively isolated production (see §3.2).

Attached or independent specialists and transmission of ceramic knowledge

Techniques which require a high degree of skill, such as wheel-throwing, will be transmitted between specialists either being attached to a locale, or independent and even itinerant. In the last case, they can be responsible for introducing the wheel to other areas, and finally in transmitting the knowledge to local potters (§2.2.4).

Chaîne opératoire as the ideal level of analysis

The *chaîne opératoire* is similar to genetic code in biological evolution, but can only be inferred from phenotypical characteristics (characteristics of the pot) and experimental reproduction (§2.3.7). Unfortunately the *chaîne opératoire* itself is not retained in the object but transmitted between potters. Ceramic vessels are the phenotypic result. As such the *chaîne opératoire* is the ideal technical level of analysis when studying ceramic evolution, and even though it cannot be fully reconstructed, should at least be the basis of evolutionary studies into material culture.

Level of transmission

The level of transmitting ceramic knowledge is from individual to individual, but perhaps more effectively studied on the level of groups of potters. This does relate to the scale and unit of analysis (§2.2.4).

Unit of analysis

The household or workshop unit which represents a group of potters is a good unit of analysis, depending on the ability to define it in the assemblage of a site. Ceramic

evolution can be studied within a group, or between these groups, both in space and time. In this sense, debates about vertical, horizontal and diagonal transmission become less useful as within the analytical unit of production of a group of potters, all these mechanisms will play a role (see **Fig. 2.2**). Moreover, the agency of objects to transfer knowledge has been under-appreciated in this discussion, but is fundamental in understanding some aspects of the transmission of traits, as objects have specific technical agency which can be transmitted over substantial distances, without the producer and potter incorporating its traits ever coming into contact

The use of the wheel is important in terms of workshop setting

The use of the wheel for throwing vessels is based on extensive learning, experimentation and transmission of skill. As such it likely occurs within a constricted setting such as a workshop, with teacher and pupil. In addition, the introduction of the wheel to form vessels, and specifically the development of wheel-throwing techniques, is likely to show a clearly recognizable evolutionary pattern (clear phylogenetic signal, see chapter 3).

Wheel and decoration: diametrically opposed?

The introduction of the technique of wheel throwing has a high efficiency potential and when this becomes a selective advantage (though not necessarily introduced for efficiency, see **§2.3.4**), it might influence other techniques used in finishing vessels such as slip and painted decoration. With increasing attention paid to wheel-making, and in particular wheel-throwing, and its potentially role in speeding up the overall production, potters can decide to spend less time and attention to smoothing the vessel after forming, or applying a slip and painted decoration.

The visibility of traits and ease of transmission

The more visible a trait, the more easily it will spread by other means than vertical transmission (learning in the same social context), such as via processes of borrowing, and learning from people outside of the immediate potter's community. *Vice versa*, the less visible a character, the more prone it is to be related to more localized learning processes, displaying vertical transmission (**§2.4.9**).

The skill involved

Combined with visibility, technical ceramic traits which take less skill to produce, or are less entrenched in a particular *chaîne opératoire*, and will be copied more easily.

Scale and transmission

In terms of descent with modification, transmission of knowledge within groups can show signs of descent with modification from a common ancestor in a branching pattern. Yet importantly, horizontal transmission on small geographical and temporal scales can be similar in pattern to vertical transmission on a larger geographical and temporal scales (between populations). For example, communities of potters within the Eastern Mediterranean can imitate designs and techniques communicated over long distances, appearing as horizontal (copying) in the local assemblage. However, these processes can lead to an evolutionary pattern of descent with modification between these separated communities of potters, as such depending on the time-scale or geographical scale we use. Transmission between cultural groups on a larger geographical scale; say communities of potters in the Northern Levant, Cyprus and the Egyptian Delta, can be responsible for an evolutionary pattern in a particular style of ceramic vessel such as Tell el-Yahudiya ware (see chapter 4).

The agency of persons and objects

The agency of transmission of ceramic knowledge can relate to multiple factors. One factor we focus on here is the agency of objects in transmitting knowledge on ceramic production. As explored above, this depends on two dominant factors; the visibility of the technique, and the capacity of the appropriator to 'imitate' this skill. The latter depends on the skill of the individual potter, and on the general level of skill (specialisation) of potters within the society.

A balancing act: emic standardization and cost-benefit for the potters

It can be suggested that there might be friction between a particular style being socially mandated (emic standardization) and mandated by cost-cutting strategies. This seems a balancing act. I suggest that when objects are primarily geared towards emic standardization and acceptance within a particular social situation they fulfil a key role in negotiating such new social situations within or between groups of people. This can lead to increasing investment in stylistic traits such as decorative patterns to make the ceramics stand out. However, once they have fulfilled this role, the

producers can give in to effort-reducing cost-cutting strategies, as the objects are established within their social niche (Costin 1991-38), and so in terms of production, time and expense can be minimized. It can be argued that this is a driving factor in the simplification of ceramic decoration after an initial quick rise in decorative motifs, for example as seen in the Halaf period in Mesopotamia (Nieuwenhuyse 2007). To cite a possible modern parallel, one could see the time and expense to produce a work of art as reducing (more about freedom of expression), once the ‘niche’ of the art; say the idea of a gallery or museum, is created. The work itself does not need to show great artistic skill and time investment because it is already literally framed as art. This process is particularly relevant when the objects fulfil a particular social role, having a particular social significance, such as in funerary rites. I suggest that this curve is general and will be repeated through history (long-term development) and is responsible for the development of new styles followed by ceramic strategies which reduce the quality, or express less skill in manufacture, once objects become more widely accepted in use and as such less ‘distinctive’. The same process has recently been referred to by Glatz (2015a, 17) as a ‘swinging pendulum’. In terms of evolutionary studies, these movements drive ceramic evolution like *conjectures* within the long term (*longue durée*: after Braudel 1972). In terms of evolutionary studies, these movements can make the analysis of ceramic evolution complicated, as they might result in ceramic traits that reappear at periods separated in time, but leading to close similarity in vessel design and decoration (see character reversal: see §3.5).

Chapter 3

Methodology

3.1 Cultural evolution

3.1.1: Evolution as a metaphor or explicit framework

The use of the word ‘evolution’ is widespread in modern day archaeological literature; yet has different connotations and often remains undefined (Greene 2004, 161-162). Evolution finds its use in more than one theoretical framework, such as evolution in a *Spencerian* sense (after Herbert Spencer), and concerned with development of societies and social organization, human behavioural ecology, and material cultural evolution (Mesoudi 2011, 37; Riede 2010; Shennan 2002; Shennan 2011). However, modern cultural evolution specifically criticizes and distances itself from ‘Spencerian’ notions of progressive evolution (kicking down the evolutionary ‘social ladder’). This thesis will foremost deal with material cultural evolution, being specifically applied to ceramic studies, and the use of a more explicit Darwinian framework of descent with modification from a common ancestor (Shennan 2011). Crucial to the method is the transmission of cultural traits (heredity), the variability in traits, and selective advantages of certain traits (adaptation) (Mesoudi 2011, 27-37; Shennan 2011). The similarity between biological evolution and material cultural evolution, particularly in terms of novel ‘adaptive’ traits which evolve in a branching pattern might be illustrated by comparing the evolution of Darwin’s finches, notably the hereditary variability in beaks adjusting to food patterns (adaptation) with the material cultural evolution of a set of pliers evolving to fulfil different tasks (**Fig. 3.1**)

A wide range of recent studies have analysed the evolution of material culture using quantitative methods borrowed from biology. These phylogenetic methods, exploring the branching pattern of material culture, range in scope from prehistory to ethnographic records, and from lithic to textile (Collard *et al.* 2006a; 2006b; Lipo *et al.* 2006; Lycett 2007; 2009a; 2009b; 2015; O'Brien 2014; O'Brien and Lyman 2003; Tehrani and Collard 2002; 2013). Moreover, the methods have been applied to studies of language evolution, oral transmissions (stories and fairy tales) and even script (Wichmann *et al.* 2011; Gray and Atkinson 2003; Gray *et al.* 2010; Tehrani *et al.* 2015; Skelton 2008). Specific case-studies focussing on ceramics, while still

relatively rare, can now be added to this expanding field (Cochrane 2004; 2009a; 2009b; 2013; Cochrane and Lipo 2010; Hood and Valentine 2012). Despite a wide range of recent applications of quantitative evolutionary methods to material culture, which are addressed using various new approaches (Lycett 2015), challenges still remain with their application to ceramic studies. An important part of this thesis aims to evaluate the prospects and problems of phylogenetic approaches to ceramic studies specifically. Let us now go into more detail on phylogenetic methods and look at some of the issues raised.

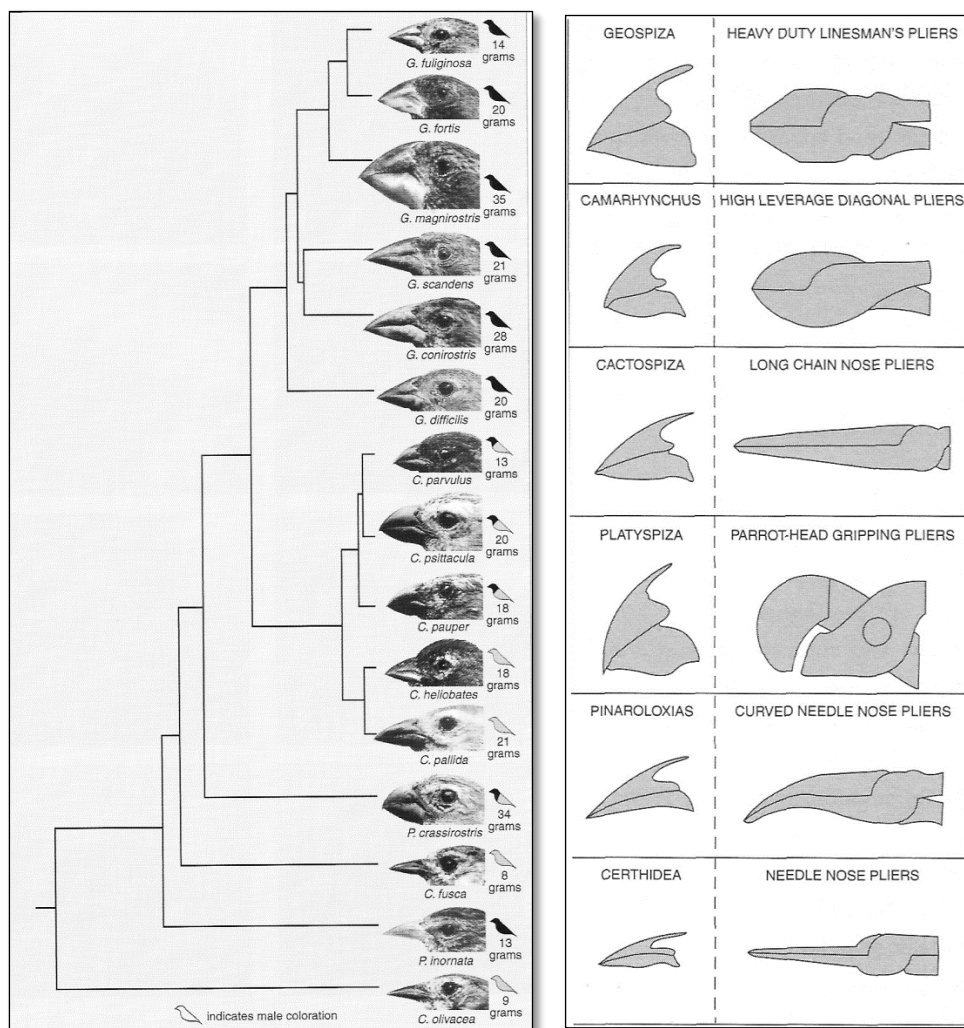


Fig. 3.1: This illustration shows the evolution of Darwin's finches on Galápagos Islands, comparing the different types of beaks with pliers (Grant and Grant 2008, 48: Fig. 5.1; Plate 1).

3.1.2: Criticizing tree-thinking

Traditional perceptions of cultural change have often accentuated the difference between biological evolution, which is ‘tree-like’, and cultural evolution, which is assumed to be blending. For example, Kroeber’s ‘tree of life’ vs. ‘tree of culture’ is often cited, where the first shows a biological ‘branching pattern’ and the latter a reticulate tree representing the intertwining of cultural traditions (**Fig. 3.2**). Nevertheless, ‘tree-like’ thinking has often been present in cultural studies, and implicitly inferred in archaeological studies (Kroeber 1948; Riede 2010).

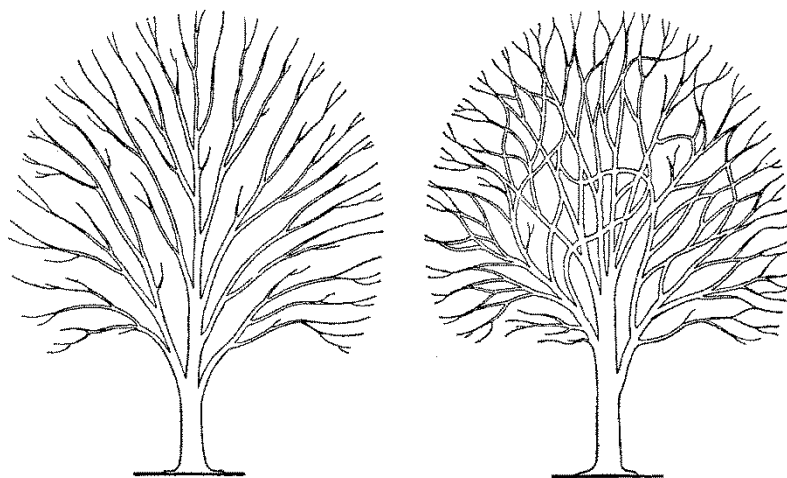


FIG. 18. THE TREE OF LIFE AND THE TREE OF THE KNOWLEDGE OF GOOD AND EVIL—THAT IS, OF HUMAN CULTURE

Fig. 3.2: Showing Kroeber’s branching tree of life vs. a reticulate tree of human culture (after Kroeber 1963 [1948], 68).

Recent advances in material cultural evolutionary studies have shown that even if the evolutionary pattern is not fully tree-like, evolutionary patterns can still be quantified, and patterns of transmission qualified. In this sense, the ‘branching vs. blending’ discussion becomes an invalid argument vis-à-vis refraining from the use of evolutionary approaches, as even developments which do not fully adhere to a tree-like pattern can be analysed. The focus should thus shift to incorporate these various ways of cultural transmission, trying to quantify them and qualify them archaeologically. Even in biology methods are implemented to deal with non-tree like data and processes of hybridization are significant (Grant and Grant 2008; Gray *et al.* 2010). Within material cultural studies notions of hybridization and hybridity have seen a recent resurgence, being pursued as specific topics within different

archaeological settings (Burke 2009; Maran and Stockhammer 2012; Stockhammer 2012). Evolutionary studies of material culture have moved on from seeing hybridity as a methodological problem and are looking for ways to analyse these different means of knowledge transmission (Collard *et al.* 2006b; Gray *et al.* 2010; Lycett 2015; Tehrani and Collard 2009b).

3.2: Vertical, diagonal and horizontal transmission

Within human culture, cultural traits can be transmitted in various ways, not just by parent to offspring transmission (Boyd and Richerson 1985; Shennan 2002; Tehrani and Collard 2013). Distinction has been made between three main ways of transmission on the individual level, namely: vertical, oblique and horizontal transmission (Mesoudi 2011; Shennan 2002; Tehrani and Collard 2013). Vertical transmission is seen as the transmission of knowledge from one generation to the other within a particular group (Boyd and Richerson 1985; Tehrani and Collard 2013). This can occur for instance within a household of potters.

Oblique transmission is the learning of traits which are acquired through often specialised knowledge of unrelated members of an older generation, for instance teachers, master crafts-(wo)men or specialised potters (Cavalli-Sforza and Feldman 1981; Tehrani and Collard 2013, 2).

Horizontal transmission signifies the transmission of knowledge (copying traits), from unrelated members of the same generation (Tehrani and Collard 2013, 2). As we have discussed in chapter 2, this copying can either be direct, for instance potters from different communities communicating their craft, or via the copying of traits from finished products which are acquired through trade, barter, or otherwise. Horizontal transmission can thus have different types of agents (see chapter 2). Burke (2009) has suggested we view these phenomena as different types of hybridization. However, as noted in the previous chapter, on a macro level descent with modification can show both branching and blending patterns when a type of artefact, say a type of ceramic vessel, evolves through being adopted by distinct groups of potters, subsequently adapting through time.

Accordingly, the difference has traditionally been drawn between evolution as a branching pattern with traditions splitting off, giving a tree-like pattern (phylogenesis) or the evolution on the basis of borrowing, mixing, called ‘ethnogenesis’ (Tehrani and

Collard 2002). However, the discussion has moved on from this dichotomy as subsequent work has shown that material cultural evolution is neither branching nor blending, but incorporates both these processes, due to historical, social-cultural and geographical reasons. It becomes necessary to quantify and qualify these different processes when analysing the evolution of material culture.

3.3: Transmission Isolation Mechanisms

The idea that branching evolution patterns are maintained in cultural groups due to ‘Transmission Isolating Mechanisms’ (TRIMS) has been suggested by a number of authors (Durham 1990; 1992; Mesoudi 2011, 101-102; Tehrani and Collard 2013). These isolating factors regulating cultural transmission can be geographical (spatial restrictions, geographical barriers), socio-cultural (language, beliefs, and tension between groups) or technical (difference in skills). Tehrani and Collard have recently tested for such TRIMS within tribal carpet making and conclude that phylogenetic signals are stronger between groups than within groups, because of these isolating cultural parameters, mostly in tribal alliances regulating and structuring the transmission between groups (Tehrani and Collard 2013). However, one thing important to acknowledge (and test) would be how these barriers can be lifted at certain points. For instance, the sea can pose a barrier as a body of water, or become a connecting factor due to better sailing techniques. This example plays a role in both our case-studies, where new ideas and technologies were introduced as part of improving maritime connections (Broodbank 2013, 219: see further chapter 7). A good case in point is the extensive borrowing shown in basket-making among native North American groups in California (Jordan 2009; Jordan and Shennan 2003). These factors are important when considering ceramic evolution and transmission between cultural groups. As discussed in the previous chapter social, environmental and technical limitations can pose such boundaries on the spread of ceramic practices.

3.4: Units of transmission

The unit of analysis has traditionally been assumed to be from individual to individual between generations; specifically parent and offspring (Tehrani and Collard 2009b). However, other units of analysis, such as larger groups, can be seen as valid units of analysis. Transmission between groups has been seen as vertical transmission (ethnogenesis). Recent work shows that studying material cultural evolution on the

group level is a valid unit of analysis (Tehrani and Collard 2009b). This approach is followed within the case studies in this thesis for various reasons. Foremost, the individual level remains hard to ascertain archaeologically, although it can be inferred on epistemological grounds. Changes are thus always made on the individual level but cannot be easily identified and isolated at this stage. Secondly, ethnographic studies have shown that a group of potters is the ideal unit through which to analyze ceramic evolution and its relation to selective pressure (Arnold 2008, see chapter 2). Thirdly, when dealing with ceramic data, the group level gives a better scope in terms of temporal and spatial scale.

3.5: Problems and challenges

There are particular challenges posed to evolutionary approaches by an archaeological dataset. One issue is quantity: how representative is the selected data for analysis in showing the full scope of material cultural evolution of a material cultural group? Secondly, often the unit of analysis has to be inferred. Unless very detailed knowledge is available on the origin of the ceramic vessels, or they were found in actual context within a production unit, this unit must be inferred from the data. The third major problem is the quality of the data. Some studies on material cultural evolution use simulated data, for instance digital Acheulean hand-axes or examples made from polystyrene (Kempe *et al.* 2012; Mesoudi 2008). One might wonder if the role of the raw material, so intrinsic to archaeological thinking about material cultural change, does not become too much of a secondary concern in this way. Neither do we have the anthropological luxury to observe the *chaîne opératoire* in person or analyse more complete, recent datasets. Archaeological data is inherently incomplete. Added to this problem is the necessity of working with published data which might not fully acknowledge the *chaîne opératoire*. As discussed in chapter 2 (§2.3.7), steps along the production process might be obliterated or hard to recognized, and unless specifically noted cannot always be inferred from ceramic data as published in archaeological literature, or drawings of vessels lacking such detail. Ceramic data can be used when only partial information is available, such as in the case of decorative schemes or rim-fragments (Cochrane 2004; 2009a; 2009b; 2013; Cochrane and Lipo 2010). However, limiting phylogenetic analysis to only one part of ceramic vessels will yield no insight in the difference of transmission of particular traits within a ceramic industry. Challenges posed by material cultural evolution

showing considerable development based on borrowing of traits, which can disrupt a branching pattern, can now be countered by new methodologies such as phylogenetic network analysis and theoretical frameworks allowing for borrowing (Gray *et al.* 2010; Huson 2010; Tehrani and Collard 2013).

Lastly, the evolutionary framework can be conceived of as constricted, being too ideopraxist (Bintliff and Pearce 2011; Pluciennik 2011). As such, the use of an evolutionary approach for a qualitative and quantitative ‘lens’ should not lead away from other bodies of archaeological (and cultural) theories and enquiries. Importantly, the evolutionary approach does not negate these approaches but can form a good synthesis, as recent efforts have indicated (Lycett 2015; Mesoudi 2011; Mesoudi 2015).

3.6: Phylogenetic methods: Cladistics

Phylogenetic approaches, of which cladistics is one particular methodology, make use of the Darwinian principle of ‘descent with modification from a common ancestor’ (O'Brien and Lyman 2003, 233). They reconstruct the relationships among a set of phenomena, such as species, or groups of artefacts (*taxa*) in a hierarchical tree-like model which represents either the relative or absolute time since these taxa shared a last common ancestor (Nunn 2011, 21). This can be expressed visually as a cladogram, which is based on the evolutionary model that new taxa bifurcate from existing ones, subsequently undergoing change (Tehrani and Collard 2013, 2). As such it is a model that supposes new taxa arise from the bifurcation of existing taxa, and the relationships between these taxa are defined on the basis of the relative recency of common ancestry (Collard and Shennan 2008, 22; Tehrani and Collard 2013). Hence, evolutionary time is slightly different from chronological time. For instance, a punctuated equilibrium which shows rapid change after a prolonged period of relative stagnancy can result in long branches that do not represent the actual time which has past. A cladogram will arrange these taxa in a number of bifurcating branches.

Taxa can be defined as a biological species, a particular type of artefact, or a group of artefacts showing shared characteristics (e.g. a ceramic type). Moreover, taxa can be coded as assemblages of material cultural data (thus a consistent assemblage of associated artefacts, such as a funerary assemblage could form a taxon) (O'Brien and

Lyman 2003). Characters can be defined as certain traits possessed by a taxa, and in cultural terms as stylistic and technical elements of a particular cultural tradition (O'Brien and Lyman 2003; Tehrani 2011). In this study, such characters ideally correspond to decisions taken by the potter, and encoded in the *chaîne opératoire*. Examples would include, the way in which a rim is folded, a spout or handle is constructed, or whether and where a particular decorative element is added to the vessel.

A number of different types of character changes can be defined. Characters can be divided into two main categories, homology and homoplasy. A homology is a character which is useful for cladistic analysis (also referred to as 'synapomorphy') showing similarities among taxa which are both the result of shared ancestry (sharing a recent common ancestor), and derived relative to the ancestral state of the character (a common novel trait) (Tehrani and Collard 2013). Hence, cladistics clusters taxa on the basis of the distinction between derived characters (novel traits, or apomorphies) and ancestral characters present in the last common ancestor of the group (plesiomorphies) (Tehrani 2011; Tehrani and Collard 2002). Some types of character traits are not useful for establishing a branching pattern, deemed 'phylogenetically uninformative' (see **Fig. 3.3**). These are 'symplesiomorphies' which are inherited by all taxa in the group (being constant, they are not useful to distinguish taxa), and 'autapomorphies', which refers to a novel character which only occurs in one particular taxa (thus unique) (Tehrani and Collard 2013).

It is important to realise that these characters are however useful for establishing groups in archaeological typologies, and will often form part of typological definitions (a unique type of rim, a shared way of decorating a vessel).

Lastly, 'homoplasies' are character traits which are present in more than one taxa but do not share an immediate common ancestor. In the analysis these are related to processes other than descent with modification (Tehrani and Collard 2013). These processes can include borrowing (horizontal transmission), parallel development and character reversal (see below). Importantly, in material cultural evolution, these instances of homoplasy are perfectly valid, but when using cladistics analysis to reconstruct the evolution of an artefact, they are assumed to be minimal (see Parsimony, **§3.6.3**).

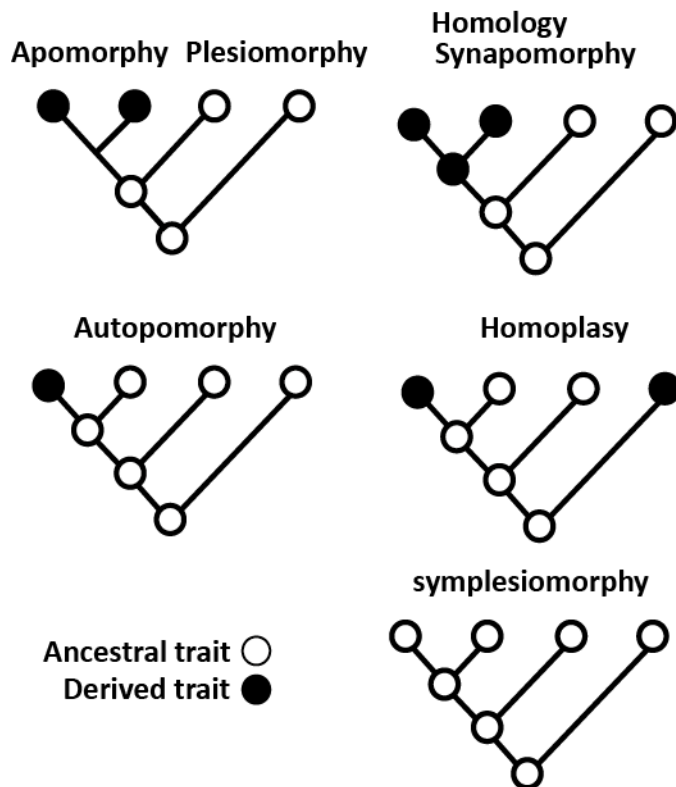


Fig. 3.3: Different types of character traits referred to in phylogenetic studies.

In order to construct a cladogram, a number of steps need to be taken. Firstly the character states need to be coded for each taxon, these states can either be binary, representing the presence or absence of a character trait (0, 1) or multiple character stages (a number of different types of rim on a ceramic vessel form, for instance). The most common way to establish which characters are novel, and which characters are part of the common ancestor (character polarity), is by defining an outgroup (O'Brien and Lyman 2003, 60). Such an outgroup is a particular taxon which shares a common ancestor with the other taxa in the analysis (ingroup) but is of more distant origin than the ancestor of the taxa forming the ingroup in the analysis (Tehrani 2011). Within archaeological data, an outgroup can usually be identified according to chronology (i.e. older it is than the other taxa).

After having established the outgroup, the branching pattern will be established by invoking parsimony (see below). This assumption dictates that the least amount of character changes necessary to explain the branching pattern of the tree is the most valid (most parsimonious). The reconstructed cladogram will show a number of bifurcating taxa. Each group of taxa showing a node can be seen to share a more

common ancestor, and represent a clade (see **Fig. 3.4**). The tree shows the branching patterns where taxa are grouped in certain *clades* (sharing a most common recent ancestor). It is important to note that the *node* represents a hypothetical ancestor, as it is assumed the ‘real’ ancestor cannot be known with absolute certainty (O’Brien and Lyman 2003, 82).

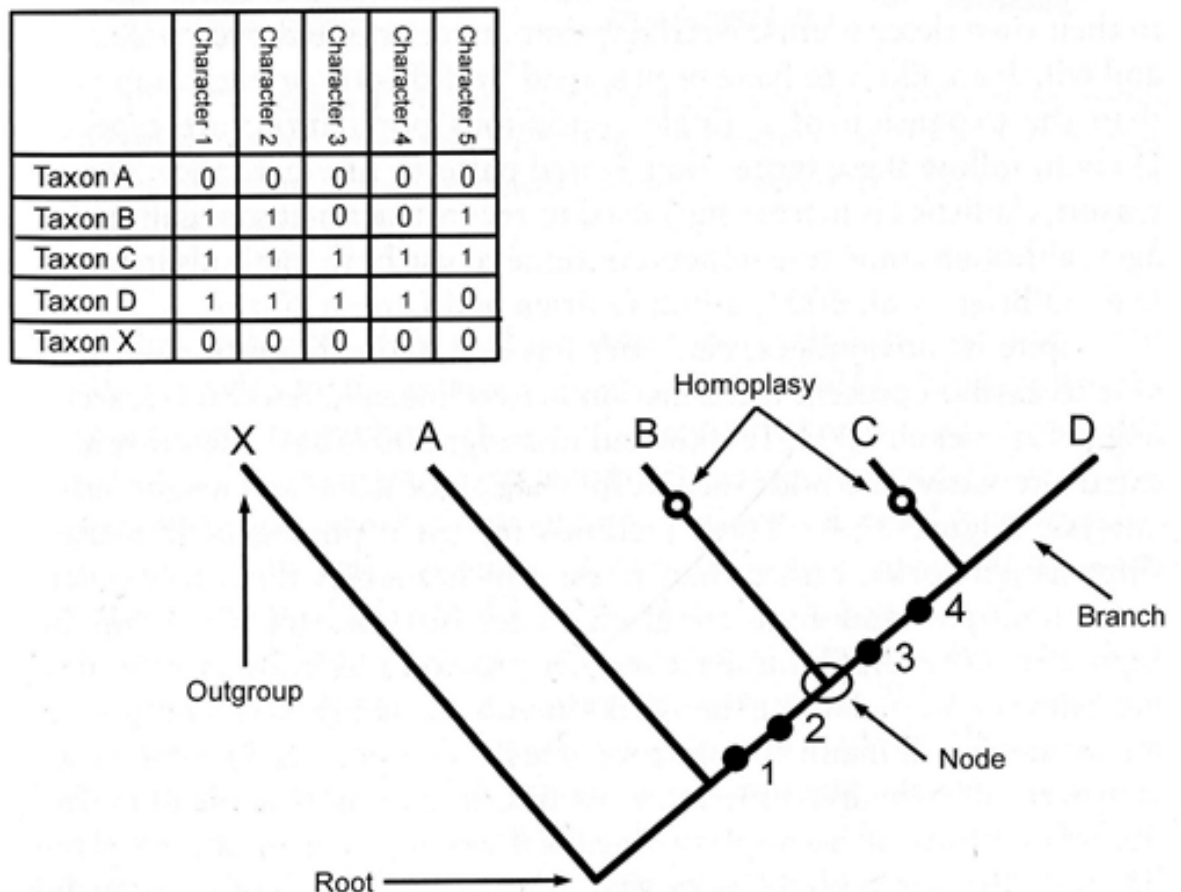


Fig. 3.4: Basic cladogram (after Tehrani 2011, 251: Fig. 11.3). The figure shows an outgroup (X) and four related taxa. The branches correspond to the character changes. The tree shows four clades, one representing X, A, B, C, another one with A, B, C, D, a third with taxa B, C, and D, and a fourth with taxa C and D. Characters 1, 2, 3 and 4 represent homologous traits, whereas the branches of taxa B and C show a homoplasy (parallel character development).

3.6.1: Choosing taxa

Choosing taxa can be done on various grounds. The decision for particular taxa needs to be well informed archaeologically. However, as O’Brien and Lyman indicate, there is no archaeological equivalent of a species in the strict sense (O’Brien and Lyman 2003, 137). They point to the problems of archaeological ‘types’ which are often ‘ideal’ categories and might be defined by only a particular character (such as a type of decoration), whereas other characters can be diverse (O’Brien and Lyman 2003,

138-139). O'Brien and Lyman's procedure for selecting taxa is rather strict, for instance excluding characters which are deemed as 'analytically important' (O'Brien and Lyman 2003, 140). This might work for their analysis of Early American projectile points (as in their case study), as these are basically created from a single fragment and a sequence of reduction. However, ceramic vessels are constructed in the opposite way, by adding element upon element, and as such are made up of constituent steps (or literally parts, for instance when a composite vessel is made). Thus, it might be problematic to exclude certain characters as not useful to define a taxa on *a priori* grounds, as it is interesting to establish which characters do contribute to a pattern of evolution, and which characters have no real part to play. This in itself can form an important part of the analysis.

The approach taken in this thesis that a taxa represents a vessel formed by a certain *chaîne opératoire*, as it is in principle this chain of actions that we are trying to follow. However, multiple vessels can make up a certain *chaîne opératoire* but show minor differences. So, taxa can be made up of a single vessel, or a group of vessels which share a number of similar steps within the production chain. By this definition, groups can differ from a traditional ceramic type, as it might only take a selected number of characteristics to define. It is more in line with a 'formal classification systems' approach to coding a number of classifiable technical characteristics for each vessel (Orton and Tyler 2013, 153-154). The ceramic taxa in this analysis differ from each other (are separated) because they show a change in one of the characters (traits) which represents an alteration in the action of the potter. The working approach taken in this thesis is that taxa are included which form variations in the *chaîne opératoire* of a certain ceramic type. As such, juglets will be compared to other juglets, but not to beakers, for instance, although they can show some similarities in the production sequence. Thus, even though vessels can show similar production methods, they are separated by intended function, following more conventional approaches in ceramic studies (Orton and Tyler 2013, 79-80). It has to be admitted that part of this process is heuristic, and an approach was taken which lets the outcome of cladistic analysis show validity of the division of taxa.

3.6.2: Choosing characters

The character coding itself is based on technical decisions that relate to forming, finishing, decorating and firing the ceramics as encoded in the *chaîne opératoire* (see

§2.3.7), with an emphasis on character traits which are recognizable in ceramic vessels, even when fragmentary. Hence, I use characteristics which are in ‘formal classification systems’ in ceramic typology to define a type, and which are deemed diagnostic in ceramic typology. For instance, the rim-type, defined by its shape and technical process of folding and pinching (Franken 1969; Rice 2005, 214), the curvature and ratio of the body (used to define shapes: Orton and Tyler 2013, Rice 2005, 219-222). Separate characteristics are coded directly relating to the *chaîne opératoire*, for instance the way a handle is formed and added to the vessel, or a spout is attached to change the function of a vessel (Orton and Tyler 2013, 81). The way bases are finished forms an important characteristic and relates predominantly to the use of the wheel, for instance the presence of string-cut marks versus smoothed rounded bases (Roux and Courty 1998). Decoration is coded in terms of surface treatment such as ‘burnishing’ or adding slip, and the way decoration is distributed on the body (panels). Decorative motifs are coded into separate characters on the basis of ‘elements’ of design, an approach in line with ‘Design Structure Analysis’ which has proven successful in past studies (Rice 2005, 254, 264, Hardin 1984). It has for instance been previously incorporated into evolutionary approaches by Shennan and Wilkinson (2001).

Breaking up the characteristics into separately categorised units is a necessary approach in the second case study, but also allows us to include more fragmentary ceramic material. However, it is important to attribute as many definable characters for the analysis, where absence of information may weaken the phylogenetic analysis.

3.6.3: Parsimony

Within this framework, *parsimony* is used in order to find the most likely tree. As such homoplasy can yield conflicting data. For instance, the taxa ‘C’ in the above cladogram could either be grouped in a clade with taxa ‘B’ or ‘C’ (see **Fig. 3.4**). Parsimony is invoked to resolve this conflicting data. In the above cladogram, C is grouped with D on the basis of parsimony; as fewer character changes are necessary to explain the branching pattern. The parsimonious assumption requires that the tree which shows the least character changes over time is the most parsimonious (Nunn 2011, 30). Thus, parsimony will result in a tree (or more often a number of trees) with the minimum number of character traits required to explain the branching pattern.

Correspondingly, the tree length will be the number of character changes necessary to explain the branching pattern.

The rationale for parsimony is based on the idea of *Ockham's razor* which states an idea attributed to William of Ockham that in order to explain a phenomenon, one should not make more assumptions than are necessary. Hence, a parsimonious hypothesis with equally weighted data minimizes the number of assumptions on character transformation required to explain the evolutionary pattern (heritable variation) among a class of taxa and as such, it can represent the 'objectively optimal phylogenetic theory' (Kluge 2005, 29). In this way, it assumes that homology is the more likely explanation for change, and instances where character changes are not due to descent with modification from a common ancestor, such as copying, or parallel developments, are less likely. Moreover, it can be seen as a model which works with a hypothesis of the maximum frequency of homology and independency of character (Kluge 2005, 38).

In material cultural evolution, where we may assume a considerable presence of homoplasy as a result of horizontal transmission between taxa (see above) we should consider the *parsimonious* model of 'descent with modification' as used in cladistics as the null-hypothesis. In reality, cultural transmission probably shows such a degree of spatial and temporal freedom that it is impossible to model exactly. This should not be an argument to refute models in general, or even in attempting to develop models that come close to explaining observed patterns. As mentioned above, models should be seen as approximations of actual historical cultural processes that might explain variability and patterns in the material cultural records as closely as possible (Collard *et al.* 2006b; Matthews *et al.* 2011; O'Brien 2014; Tehrani and Collard 2009a; 2013). A parsimonious model of evolution would be one of the most basic models to start with and might show where the archaeological information appears to be in disagreement with the model.

What is important in the end is that any explicit model, be it parsimony or a more complex modelling system (using for instance Bayesian inferences to build upon previous archaeological information), can be tested and accepted or refuted, both on the basis of the internal consistency of the reconstructed evolution and whether they can be observed to fit the 'real' data, be it archaeologically, anthropologically or

biologically retrieved (Matthews *et al.* 2011). As such they offer a testable model instead of a looser hypothesis. Moreover, and increasingly important, they make it possible to compare developments in different regions on the basis of shared methodology and terminology, helping to show key similarities and differences. In the end, one could wish for computational models which are predictive, hoping to show cultural evolution under different conditions, and being able to reconstruct *alternative* trajectories.

3.6.4: Qualitative vs quantitative characters

Both quantitative and qualitative character traits are used in this thesis, however with a pre-dominance towards qualitatively-defined ceramic characteristics. Quantitative measurement of vessels can pose a problem either due to the nature of published material (drawings are not always very accurate), or where the vessels are incomplete. However, when dealing with more complete datasets, quantitative data should, and can be measured in more detail (Eerkens 2000; Gandon *et al.* 2011; Gandon *et al.* 2014; Sterling 2015).

Decorative motifs form an important qualitative set of character traits. Basic design patterns were defined and coded by being present or absent. The advantage of qualitative character data is that with groups of potters as the unit of analysis (or an individual working within a group) qualitative traits are easier to recognize and code, even when quantitative data is absent, due to incomplete or insufficiently published data (such as drawings, etc.). The character coding will be discussed in more detail regarding the particular case-studies in the following chapters.

3.6.5: Independence of characters

It has been repeatedly stated that characters need to be independent, in order to avoid redundancy (Lycett 2009b, 4; Nunn 2011, 25; O'Brien and Lyman 2003). In particular, Lycett has analysed characters for dependency using Pearson's test for correlation and excluded characters that failed this test (Lycett 2009b, 4).

A more qualitative approach is taken in this thesis. The evaluation of dependency of characters is based on those steps within the *chaîne opératoire* which can be taken without affecting other steps. However, this poses a problem in the study of ceramics, as material (clay and temper), and the use of the wheel, for instance, can pose

restrictions on the initial steps along the line and will influence later steps. This dependency vs. independency was explored using experimental replication of juglets (in the first case study) and inferred for the second case study based on the idea that a potter could have made the decisions independently; for example choosing to add slip or not, or folding the rim or not.

The character coding itself is based on technical decisions in forming, finishing, decorating and firing the ceramics. The emphasis lies on character traits which are recognizable in ceramic vessels, even when fragmentary. This is a necessary approach in the second case study, but also allows the inclusion of more material. However, it is important to attribute as many definable characters for the analysis, where absence of information weakens the phylogenetic analysis.

3.6.6: Choosing an outgroup

The choice of a particular outgroup is important, as it provides the direction of the tree and will influence the outcome of the branching pattern. Chronological information can be used to determine what is assumed to be the group closest to the ancestor. Moreover particular characters can be defined to be ancestral on the basis of inferences regarding the transmission of cultural traits through time, for instance the presence of these characters in earlier related cultural assemblages. The choice of outgroups will be discussed in the relevant chapters.

3.7: Types of character and transmission

An important part of this thesis is the role of technical traits and decorative traits, and the way these might be transmitted differently. Importantly, despite the fact of variations in transmitting these traits between potters, decorative traits can evolve just as much in a branching pattern, if not more so than technical traits (Tehrani 2011). In the previous chapter the hypothesis stated is that more visible character traits (such as decoration) are more likely to be borrowed, and thus more prone to show horizontal transmission. Nevertheless, these traits can still show a clear phylogenetic pattern, as suggested by analysis of designs on tribal carpets (Tehrani *et al.* 2010; Tehrani 2011).

Recent advances in in phylogenetic methods have shown that a core tradition can support a phylogenetic signal while additional (peripheral) characters can be based on horizontal transmission (Tehrani *et al.* 2010). This principle could be present where a

core tradition of ceramic making is transmitted between close communities of potters, but external and more visible characters such as decorative motifs and general shape features can be borrowed and incorporated into local production. As discussed in chapter 2 (§2.4.1) these differences in character transmission might rely on the visibility of the character, and the skill set within a community of potters.

3.8: General methodology: Character coding in ceramic studies

As discussed in chapter 2, the *chaîne opératoire* is a key conceptual framework with which material cultural evolution can be analysed. In the case-studies, I try to define characters on the basis of decisions within the *chaîne opératoire*. It is thus important to keep in mind that ceramic vessels consist of a variety of steps in production, from clay procurement to preparation, forming, finishing and firing, and that these steps can be dependent on each other to various degrees. In this way, characteristics can be coded in quantitative (size-groups, morphology) or qualitative terms (a certain type of rim). An advantage is that even when measurements are problematic due to fragmentation or insufficient publication, qualitative data based on steps within the *chaîne opératoire* can still be identified and coded.

In the first case study, these characters are chosen on the basis of published data and illustrations, aided by experimental reconstruction of a subset of juglets. Quantitative data is obtained from published and illustrated measurements. In the second case study, the characters are coded on the basis of published and material examined at first hand, mostly making use of qualitative data because of the fragmentation of the vessels (see Chapter 5-6). In this case, vessel fragmentation inhibited detailed morphological measurements (save the rim diameter), yet general morphological groups could still be identified on the basis of the profiles used when drawing the vessels, which should be examined in more detail when better preserved material is studied.

The problem with the *chaîne opératoire* approach, particularly on the basis of published material, is that steps within the production chain can later be obliterated. These can however be partly inferred by descriptions and drawings, experimental replication (chapter 4), and detailed examination of the material (chapter 5-6). In this thesis the *chaîne opératoire* is used as the theoretical basis, and characters are chosen to reflect different ‘steps’ within it. Yet it is acknowledged that more detailed study,

taking into account the full production chain, would enhance our ability to code ceramic data, and this will be a theme picked up in the discussion. These individual steps are susceptible to change (mutations), either dependently or independently of each other. These mutations can have selective advantages. A main point of this thesis is that this selection is primarily socially mitigated by the interaction of the potter with the social, economic and natural environment (chapter 2).

3.9: Cladistic software: PAUP*

There are different phylogenetic software programs that use this principle and run an analysis to create cladograms. In our analysis we use a program called PAUP (Phylogenetic Analysis Using Parsimony) (version 4) created specifically for this task to conduct the initial computational phylogenetic analysis (Swofford 2002). A package called Mesquite is used to code the dataset (after recording in Excel) and to analyse the subsequent phylogenetic data (Maddison and Maddison 2011).

3.9.1: Branch and bound and heuristic search

PAUP uses a number of algorithms to calculate the most parsimonious tree(s). The most commonly used algorithm is the 'branch and bound' (B&B) option. A B&B search will guarantee to find the most parsimonious solution for the branching pattern. B&B uses the stepwise addition of branches to the tree, and computes the score of partial trees each time it adds a branch. If the score of the partial tree is worse than the shortest tree retained so far, it is discarded, the search continues until the shortest possible tree is found (minimal number of character changes) (Swofford *et al.* 1990).

Besides a branch and bound search, a heuristic search can be used when the dataset is larger, and less easy to compute. An initial random tree is constructed and subsequently branches of the initial tree are swapped to rearrange the tree in order to see if the score improves (less character changes needed). Significantly, a heuristic search does not guarantee to find the most parsimonious tree, however confidence in the tree can be increased by repeating the analysis yielding the same results (Swofford 2002; Felsenstein 2004, 38).

3.9.2: Tree length

The result will be shown as a cladogram or number of cladograms. The tree length will be mentioned and corresponds to the number of character changes which are

necessary to explain the branching pattern. Parsimony will thus strive to find the shortest tree-length.

3.9.3: Consensus tree (different types, Majority rule, strict, semi-strict).

Cladistics will not always (actually rarely) give a single most parsimonious tree. When conflicting data exists, multiple trees with a similar length can be equally parsimonious. In this case, consensus trees can be drawn showing the combined result of these different trees. Usually a majority rule consensus tree is illustrative, showing the clades present in at least 50% of the equally parsimonious trees. Other consensus trees can be more restricting; a strict consensus tree, for instance, only shows the clades present in all the trees of equal length. A semi-strict consensus tree shows the clades that are not in contradiction to one of the group of most parsimonious trees (O'Brien and Lyman 2003, 68-71)

3.9.4: Testing validity

The validity of the cladistic result can be tested in a number of quantitative ways. Most commonly used are two statistics, called the consistency index (CI) and retention index (RI) (Farris 1989; Tehrani and Collard 2013, 7; Nunn 2011, 31). Another common method is the resampling technique called bootstrapping. It is worth discussing these in more detail.

3.9.5: Consistency index (CI)

The consistency index can be calculated for a single character or the entire dataset. The CI provides an indication of the measure of homology within a dataset. For a single character, the CI is calculated as: $CI = m/s$, where m is the minimum number of possible evolutionary steps on a cladogram and s is the actual number of reconstructed steps (Nunn 2011, 31). A higher amount of homoplasy results in a higher value for s (more steps on the tree). The CI for a tree is calculated by the sum for all the characters, $M = \text{sum of } m$, $S = \text{sum of } s$ (M/S). A CI of 1 would mean that the tree shows perfect homology, in other words, all character changes agree with a branching pattern. Thus, the more homoplasy we find in the data; such as character reversals, parallel development, and horizontal transmission (borrowing), the lower the CI. The CI is influenced by number of taxa and characters (Nunn 2011, 31; Tehrani 2011; Maddison and Maddison 2000).

3.9.6: Retention index (RI)

The retention index (RI), measures the amount of synapomorphy on a tree (Nunn 2011, 31; see **Fig. 3.3**). In other words, how well the pattern of the tree is explained by shared derived characters. An RI of 1 indicates that all the characters in the matrix are completely consistent with phylogeny, and an RI of 0 would indicate that none of the characters is consistent with a phylogenetic pattern; the maximum amount of homoplasy (Nunn 2011, 31). For a single character, the RI is calculated as: $RI = (h-s) / (h-m)$, where h is the maximum number of steps possible for a character, m is the minimum number of character steps, and s the actual number of character steps (like with the CI). For more than one character (or the whole set) the RI is calculated as the sum of values for the individual characters $(H-S / H-M)$.

By including the maximum number of steps possible for characters in the dataset, the advantage of the RI is that it is not affected by number of taxa or characters, making it possible to compare RI among different datasets, and as such it is favoured over the CI (Felsenstein 1985; Nunn 2011; Tehrani 2011). The assumption that a high RI would indicate a phylogenetic signal, thus a branching evolutionary pattern, has been questioned in the past (Borgerhoff Mulder *et al.* 2006; McElreath 2009; Tehrani and Collard 2013, 9). However, recent tests have shown that the RI can be taken as an indication of a phylogenetic signal (Collard 2006; Nunn *et al.* 2010; Tehrani 2009; 2013). One study, using the RI cultural datasets compared to biological datasets, showed that the cultural datasets were not necessarily more reticulate than biological datasets (Collard *et al.* 2006b). The RI of the biological datasets showed mean of 0.61, a minimum RI of 0.35 and a maximum RI of 0.94. For the cultural datasets, the mean was 0.59, the minimum 0.42 and the maximum RI 0.78 (Collard *et al.* 2006b, 177). Another study compared a cultural dataset with 1,000 random datasets and found the average RI of the random datasets, 0.35, to be lower than that of the cultural dataset; 0.59, thus concluding that randomized datasets would not readily yield high RI (Tehrani and Collard 2009b). More recently, a study generating random cladistic datasets artificially generated with varying rates of horizontal and vertical transmission show that a RI of around 0.6 or higher can be reliably inferred to show phylogenesis (Nunn *et al.* 2010; Tehrani and Collard 2013). However, even with considerable horizontal transmission (reticulation) parts of the cultural traditions might still show clear phylogenetic signals based on descent with modification from a

common ancestor, as a low RI for biological datasets readily attest. As will be shown below, other methods can be used to explore the reticulate data more closely (phylogenetic networks).

3.9.7: Bootstrapping

Bootstrapping is another method popular to check how well the branching pattern is supported, giving confidence levels (in percentages) of the various nodes in the tree. Bootstrapping resamples the original dataset (taxa and character distribution) with replacement to create a number of replicate (random) data sets of the same size. These datasets are analysed looking for the shortest tree, using parsimony, and the branching pattern present in these trees will be compared with the original result. The analysis yields percentages for the amount of time the same support for particular clades (branches sharing a most recent ancestor) are given. The bootstrap can be set for a number of repetitions, and usually 1000, or 10,000 replications are used. Bootstrap supports of 70% are seen as high and are traditionally considered to be reliable (Tehrani and Collard 2009b, 293; Hillis and Bull 1993).

However, bootstrapping is known as a conservative estimate and bootstrapping must be considered as a heuristic tool. For example, one objection is the lack of control on the quality of the randomly generated trees themselves as used in bootstrapping (Tehrani and Collard 2002; Makarenkov *et al.* 2010).

3.9.8: Reticulation: horizontal transmission and net-like patterns of evolution

Phylogenetic, tree-like evolution is not always the dominant trajectory of the transmission of cultural traits. Often the transmission of cultural traits occurs horizontally when borrowed from individuals outside one's own culture, or imitated from foreign objects (see §2.5.1 and further discussion). This phenomenon is well attested in archaeology and to be expected in periods of pronounced and far-flung cultural contacts, especially when we expect strong processes of cultural borrowing. Such horizontal transmission results in reticulation, or 'non-tree like' patterns (Nunn 2011, 241).⁶ The method has been used to explore horizontal transmission within language evolution, historical instruments and anthropological case-studies on material culture (Bryant *et al.* 2005; Gray and Atkinson 2003; Hurles *et al.* 2003; Jordan 2009; Nunn 2011, 241; Tëmkin and Eldredge 2007). This is in accord with the

⁶ Literally: "A pattern or arrangement of interlacing lines like a net": Oxford dictionary online.

approach in this thesis, where reticulation in the form of hybridization, parallel evolution and the changing back of a certain trait into an ‘older’ variant can be expected in material cultural evolution. Hybridization is particularly to be expected, due to the interconnectedness and relative ease of the spread of ideas in the Bronze Age world of the Eastern Mediterranean (see Introduction).

In order to analyse such reticulate data, and not force a strict ‘tree-like’ development, a methodology using “Split decomposition” can be used to detect horizontal transmission in cultural and linguistic data (Bandelt and Dress 1992; Huson 1998; 2010; Huson and Bryant 2006; Nunn 2011). According to Huson and Bryant (2006: 254): “Thus, phylogenetic networks should be employed when reticulate events such as hybridization, horizontal gene transfer, recombination, or gene duplication and loss are believed to be involved, and, even in the absence of such events, phylogenetic networks have a useful role to play.” The same data-set used for the reconstruction of phylogenetic trees is used to analyse the data in the form of a phylogenetic network. A software program (NeighborNet/splitsTree 4) is used to analyse the data.

3.10: Software: SplitsTree4

A phylogenetic network is defined by Huson and Bryant as (1998: 254): “any network in which taxa are represented by nodes and their evolutionary relationships are represented by edges.” They note that for phylogenetic trees (see cladistics), edges are referred to as branches. The difference is that whereas cladistics shows evolution as a bifurcating tree, with taxa grouped in clades (see above: §3.6), phylogenetic networks display the data with nodes and edges visible as lines between the various nodes. If a dataset were to have no conflicting ‘splits’, it would form a perfect tree, but when a number of taxa can be split into different groups, this conflicting data can be shown in a phylogenetic network (Gray *et al.* 2010, 3925). As such it visualizes the horizontal transmission which is seen as conflicting data (homoplasy) in cladistic analysis. A highly clustered phylogenetic network would thus manifest itself in a cladistic analysis showing considerable homoplasy.

Several pieces of software have been developed for phylogenetic networks. SplitsTree4 allows various types of such network-analyses to be performed on a dataset (Huson 1998). This software works with a similar dataset of taxa and

characters as used for cladistic analysis, however, orders the data by nodes and edges instead (for the full methodology, see Huson 1998; 2010). NeighborNet, most often used in this thesis, is a form of split-tree network which works on the basis of a distance matrix (using the same two dimensional coded dataset as the cladistic analysis containing the pair-wise distances between the elements of a set of data), showing splits as parallel edges (Huson and Bryant 2006; Huson 2010; Bryant and Mouton 2004). These splits are created progressively as agglomerative clusters while allowing for overlap, thus not necessarily hierarchically ordered but representing the data as a split-network (Gray *et al.* 2010, 3925). In this way, they can be used to represent data which is incompatible or ambiguous with a strict tree-like pattern. In such a network “parallel edges, rather than single branches, are used to represent the splits computed from the data.” (Huson and Bryant 2006, 225). A large number of such parallel edges will result in a highly reticulate network, which can be interpreted as a large amount of horizontal transmission (and parallel development), seen as homoplasy in a phylogenetic tree. Huson and Bryant (2006) note that split networks only offer an ‘implicit’ representation of evolutionary history. In principle, the method orders taxa in a network arrangement of nodes and lines, based on the similarity in traits between these taxa. It is thus primarily a visual aid which shows data in a network of connections between taxa, instead of branching. However, some statistical methods have been developed to test the degree of reticulation displayed by the data.

3.10.1: Testing validity in phylogenetic networks

Two statistical values are used to analyse the outcome. These are the Delta-score and Q-residual score (Gray *et al.* 2010, 3925). The Delta-Score (D-score) is a ‘quantitative estimate of the degree of conflict’ (Nunn 2011, 241). Both values are relative indications of the ‘tree-likeness’ of the data.

The D-score is calculated by defining the distance between a subset of four taxa (a “quartet”), with the D score of an individual taxon (Gray *et al.* 2010, 3925 for detailed explanation; Holland 2002). The score for a quartet of taxa is $m_1 - m_2 / m_1 - m_3$, where m_1 is the largest value, m_2 is the second largest value, m_3 is the third largest value and m_4 is the smallest value. The score for an individual taxon is the average of the overall quartets that contain it. The D-score of the total dataset is the sum of the score of all the quartets, divided by the total number of quartets (Gray *et al.* 2010, 3925 for

details). The Q-residual score is a related statistic which takes the square of the maximum distance (m_1) minus the second largest distance (m_2); formulated as: $(m_1 - m_2)^2$ (Gray 2010, 3925).

Basically, a score closer to 0 (zero) indicates a strong branching pattern, whereas a score close to 1 suggests strong reticulation. However, there is no absolute measure. The scores can be compared and give a relative indication of how reticulate or net-like, the data is. The scores can be compared to the CI and RI, where a low RI (indicating substantial homoplasy) would correspond to a rather high D-score and Q-residual score. These scores should thus be negatively correlated.

3.11 Character reversal/atavism

A specific problem with archaeological datasets that demonstrate a substantial time-depth is the process of character reversal (a homoplasy, see below), where a character can revert to a more ancestral state. This reversion is a homoplasy and forms a problem for phylogenetic analysis and the principle is known as atavism in biology (Stiassny 2003). In cultural terms this would be an 'archaic' trait, such as a potter copying a trait from an older vessel. Moreover, potters likely retain knowledge of a quite a wide variety of techniques and might decide to use a particular technique that not been used for some time. The flexibility of reversing back to certain older traits might be seen as incomplete speciation, for instance if the industries are not isolated for a longer period of time or isolated in space to guarantee full speciation.

3.12: Long-branch attraction

A significant problem for phylogenetic studies is "long-branch attraction" (Nunn 2011, 32). In such a situation, two long branches (showing considerable character changes/mutations) are grouped together, although they are not actually closely related (Nunn 2011, 32). This can occur when two branches show parallel evolutionary developments over a long time-span, (convergence in characters) and which is erroneously interpreted by cladistic analysis as signifying shared derived characters from a common ancestor. In ceramic terms, this might mean that over a considerable stretch of time, two types of ceramic vessels could show similar developments in characteristics, perhaps due to similar production techniques, but in two ceramic traditions that are unrelated, i.e. between which there had been no contact. An additional problem would appear when these traditions become

connected, directly or indirectly (see ceramic theory chapter) and horizontal transmission explains shared characteristics. However, this phenomenon can be countered in archaeology by carefully examining the contextual information, and additional arguments for placing types of pottery within a similar clade such as established contact between ceramic producing communities based on other material culture (Bergsten 2005). Importantly, the CI and RI cannot be taken as a direct indicator of horizontal transmission (ethnogenesis) (Nunn *et al.* 2010, 3807). In such cases, methods focusing on reticulation offer an alternative way to examine such patterns.

Having considered the methodology and some of the issues regarding phylogenetic analysis, it is time to explore these methods using the data from two case-studies set in different regions. First of these examine the evolution of so-called Tell el-Yahudiya ware and is situated in the East Mediterranean during the 2nd Millennium BC.

Chapter 4

The evolution of a Middle Bronze Age decorative ware: Tell el-Yahudiya as a case study

4.1: Introduction

Evolution has provided a metaphor for change in Levantine ceramic studies from an early stage, on par with developments in other archaeological regions, ever since Père Vincent used the term indicating change over time in his *Canaan d'après l'exploration récente* (Vincent 1907, 297; 347, Fig. 244; Riede 2010). Evolution continues in use as a metaphor in ceramic reports up to the present day and is invoked in images, but is hardly ever quantified or even specified in a systematic manner. When evolution is mentioned in the literature, it is usually used as a (loose) substitute for change over time (often implying gradualism) and the mechanisms of this change remain unexplained.

The aim of this chapter is to take a case study of well-known ceramic vessels and see if an evolutionary framework of ‘descent with modification from a common ancestor’ can actually help us understand the developments of this particular vessel group.

The ceramic group called Tell el-Yahudiya (Yahudiyeh alternative spelling) ware was chosen as it has been important in discussions about trade, chronology and even questions on ethnicity (Kaplan 1980; Aston 2008; Aston and Bietak 2012). This type of pottery is attested in the Middle Bronze Age (roughly 2000-1550 BC) and shows a distribution throughout the Eastern Mediterranean, centred in Egypt and the Levant, but extending from the ancient Nubian capital of Kerma in Sudan, in the south, through sites along the Nile and Mediterranean coast and as far north as Ebla in northwest Syria (Kaplan 1980; Baffi Guardata 1988). It has a marked presence on the island of Cyprus, and even a single contested example from Santorini (Kaplan 1980; Merillees 2009) (see **Fig. 4.2a-d**).

Tell el-Yahudiya ‘ware’ (I will return to the matter of the term ‘ware’ in the discussion) groups together a range of vessels, predominantly juglets, but also less frequently open vessel forms (bowls and cups) and animal shaped figures (see below). However, juglets dominate the group. The most distinguishing feature is its surface

treatment. Tell el-Yahudiya ware features decoration of indented lines and dots applied by a single pointed tool or multi-toothed comb to the leather hard surface of the vessel before firing, and the general surface of the ware is polished or burnished and has a dark hue (due to a reduced atmosphere during firing). In most cases (though this is not always mentioned or fully preserved) the indentions and lines are filled with a white paste, which is presumably calcium-based but has not (to my knowledge) been chemically tested (**Fig. 4.1**).



Fig. 4.1: Typical example of an early Tell el-Yahudiya ware juglet from Middle Kingdom el-Lisht. It has a reduced fired dark burnished surface and shows white infilled motifs organized within multiple panels. Note that the upper part of the juglet is reconstructed (With permission from the Metropolitan Museum of Art: <http://images.metmuseum.org/CRDImages/eg/original/MMA34.1.17.jpg>).

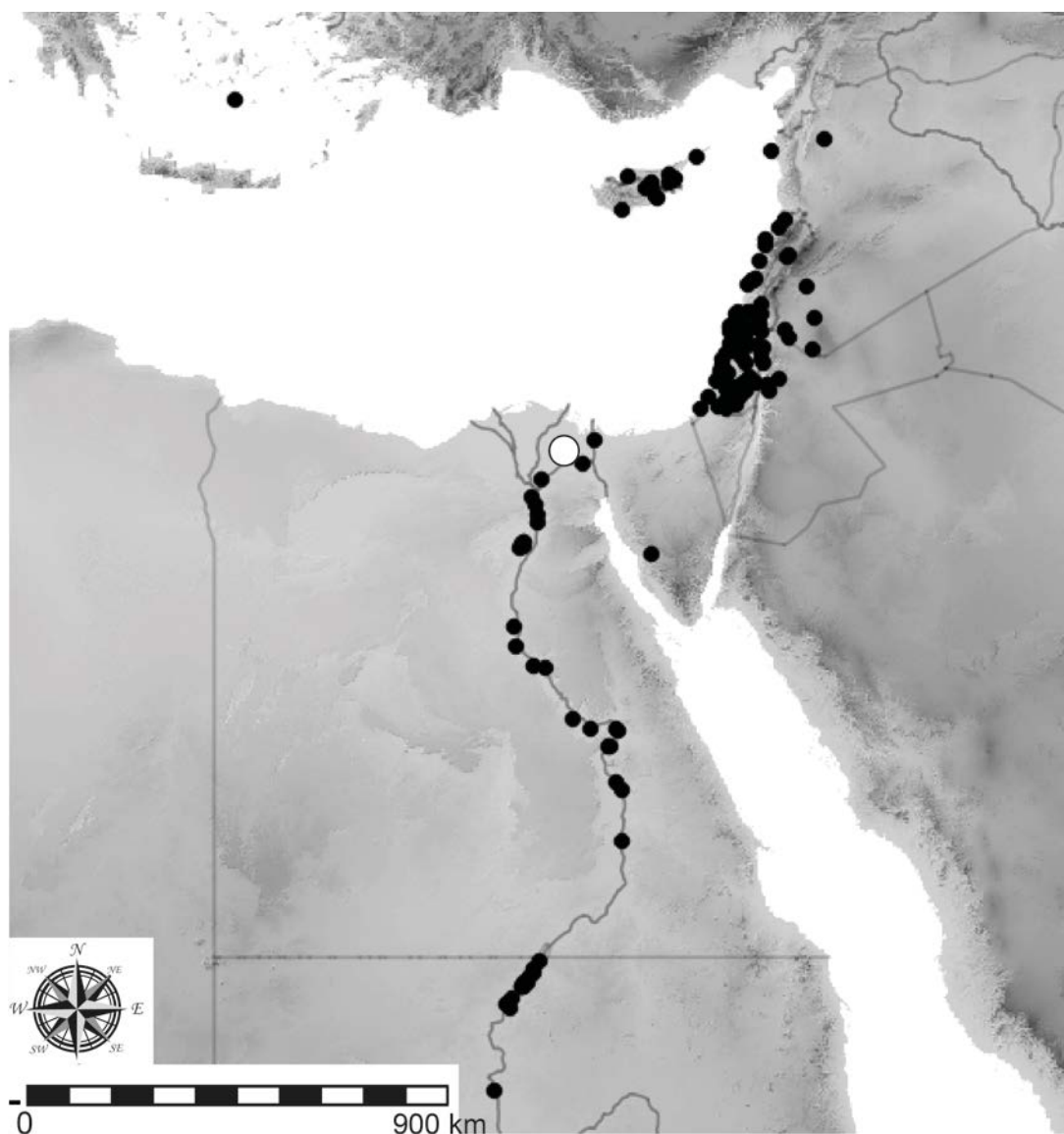


Fig. 4.2a: Map indicating the distribution of Tell el-Yahudiya juglets during the Middle Bronze Age: stretching from Kerma in Nubia to Ebla in Syria and all the way to Santorini in the Aegean. The pivotal position of Tell el-Dab'a (in white) is clearly visible (See Fig. 4.2b-d for detail: Background map SRTM 90m DEM courtesy of NASA: Map created in QGIS 2.8.1).

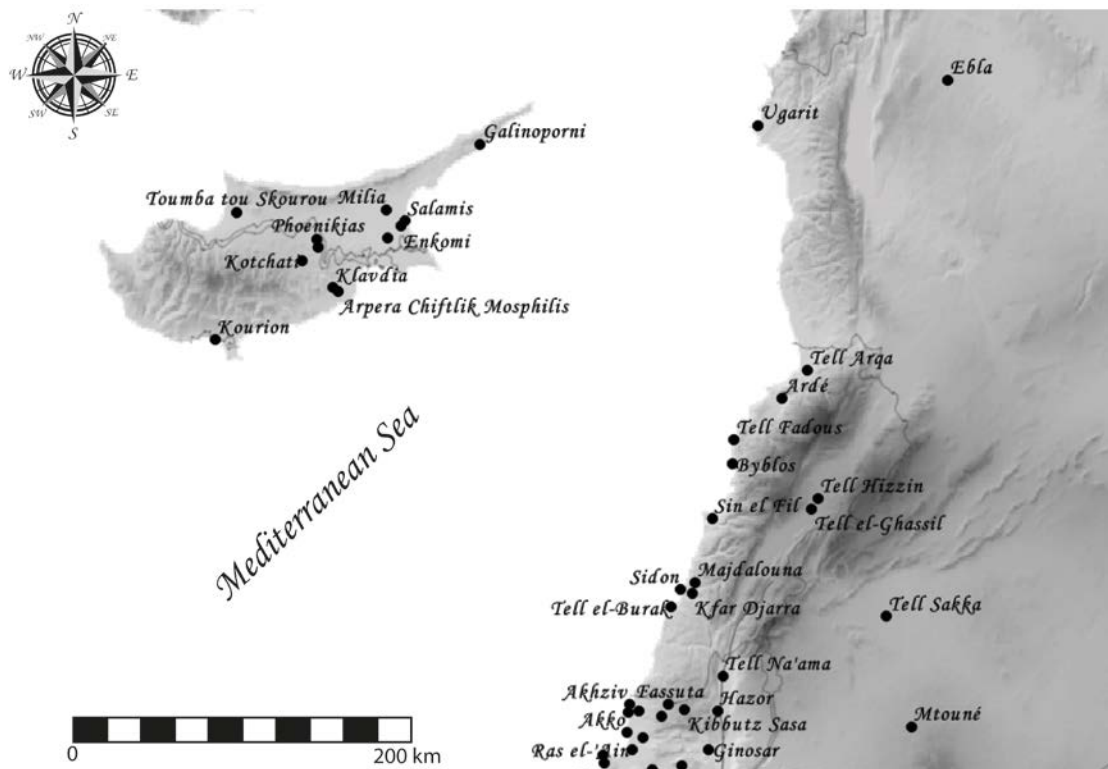


Fig. 4.2b: Sites with attested Tell el-Yahudiya ware in the Northern Levant and on Cyprus (Background map SRTM 90m DEM courtesy of NASA: Map created in QGIS 2.8.1).

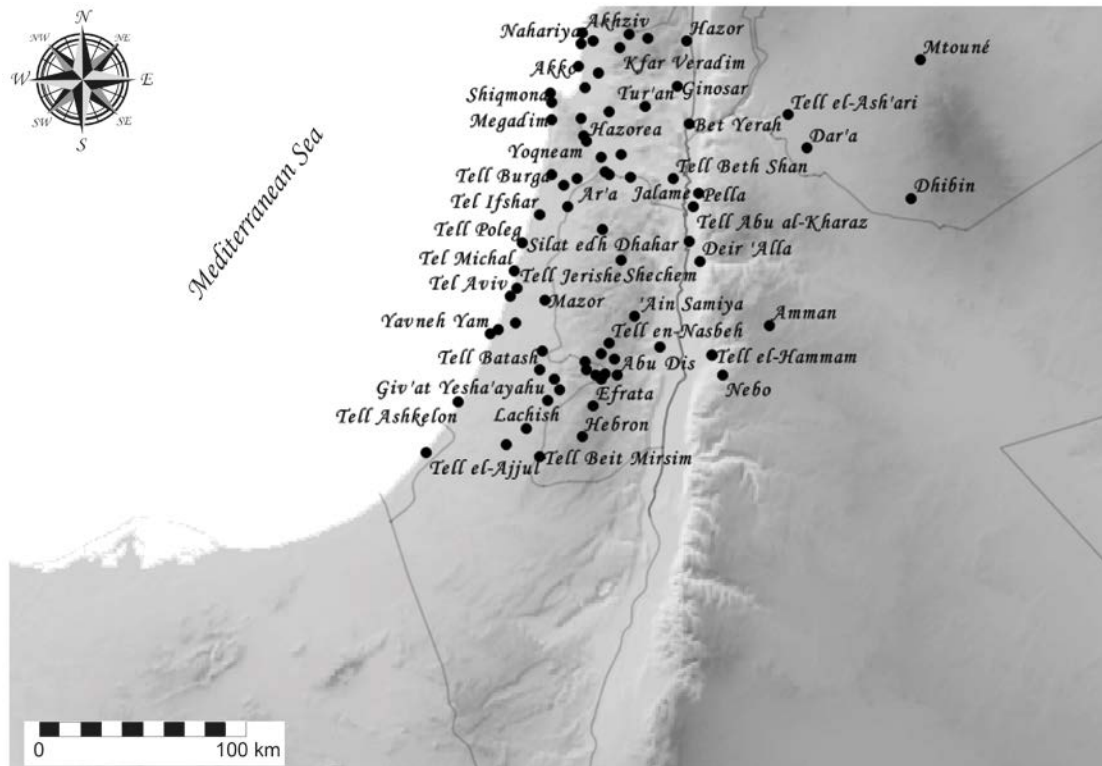


Fig. 4c: Sites with attested Tell el-Yahudiya ware in the Southern Levant (Background map SRTM 90m DEM courtesy of NASA: Map created in QGIS 2.8.1).

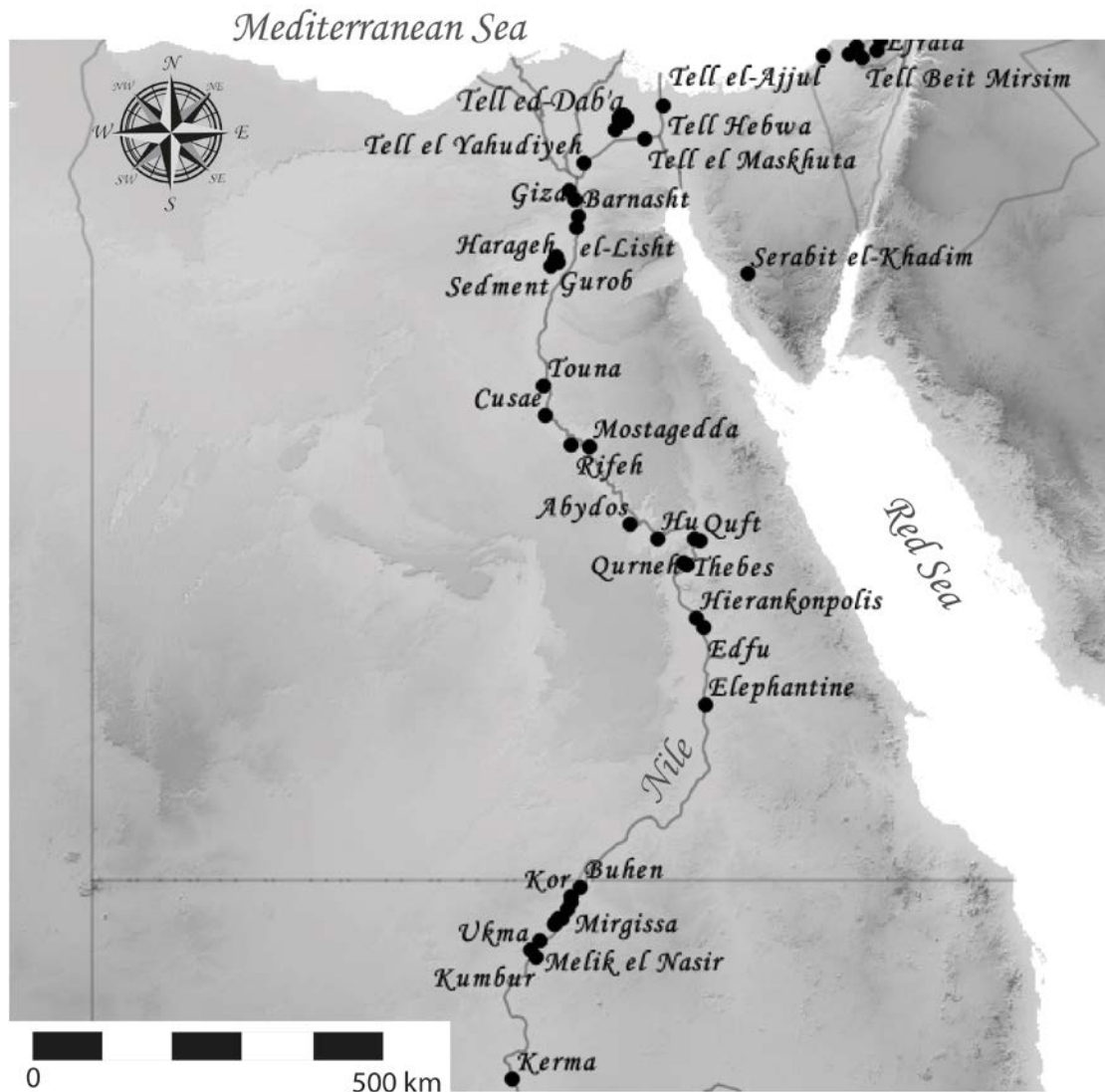


Fig. 4.2d: Sites with attested Tell el-Yahudiya ware in Upper & Lower Egypt, and Nubia. Kerma is the southernmost site where Tell el-Yahudiya ware is attested (Background map SRTM 90m DEM courtesy of NASA: Map created in QGIS 2.8.1).

The ware is called after a site in the Egyptian Nile Delta *Tell el-Yahudiya* (literally Mound of the Jew: see **Fig. 4.2d**) which was excavated in the late 19th and early 20th centuries and yielded vessels of this type (Griffith 1890; Petrie 1906). It is not the only ceramic ware that was decorated in this way around the period and received this surface treatment, as the same surface treatment is attested in Nubian ceramic traditions (Arnold and Bourriau 1993, 90; Reisner 1923) and in the ‘Black Slip Ware’ and ‘Black Polished Ware’ of the Middle Bronze Age in Cyprus (Åström 1957, 88; Åström 1972; Frankel 2014, 491). Despite the overlap in method of decorating; i.e. with reduced firing and white infilled incised decoration, Tell el-Yahudiya vessels distinguish themselves by the use of certain decorative motifs and the occurrence of

certain vessel shapes (see below). However, it is significant to already observe that the category of Tell el-Yahudiya ware can be seen to touch ‘fuzzy’ boundaries where the ‘ware’ is overlapping with ‘Black Slip Ware’ on Cyprus, and ‘Nubian style’ ceramics at its southern most distribution. This in itself raises important questions about hybrid practices of decoration, which are easily shared (§2.4 and below) and probably relate to shifting perceptions of these vessels within different societies.

Not all vessel shapes are decorated with this pattern. It is predominantly juglets, small container vessels with constricted necks that bear this type of decoration, although open forms such as bowls and goblet are also attested, and animal shaped containers with restricted necks are found (Kaplan 1980, 29-33; Aston and Bietak 2012, 81; 228-295). This in itself attests to the way decoration might easily transmit to other shapes and types of (ceramic) objects. In our study, we will however mainly focus on juglets, as they a) constitute the main body of evidence, and b) form a well-defined assemblage where we can attest the interplay of change in general shape, morphological features and decoration for a single type of vessel.

Tellingly, the term Tell el-Yahudiya ware has often been applied to include similarly shaped juglets which bear a different surface treatment such as painting or slipped and pattern burnished surfaces (Aston and Bietak 2012, 25). It can be argued that, in terms of the *chaîne opératoire*, the variation in decoration just reflects a few different steps taken along the line of production, and if we were to translate this in genetic terms, it would mean just a few mutations in the DNA-strain causing the phenotypic differences (see §2.3.7). As a result, juglets with different surface decoration, such as painted lines or burnished and slipped surfaces, can easily be seen as related taxa in a phylogeny of the evolution of Tell el-Yahudiya juglets (see §3.6). However, for now, I have kept to a strict definition of Tell el-Yahudiya ware with its separate distinctive decoration in order to analyse the transmission of characters within this visually clearly demarcated group. It is, however, important to keep in mind, and we will return to this point again, that for a workshop of potters, the distinction might easily have been seen as a few different steps incorporated with relative ease, and they likely created juglets decorated in different manners within the same working environment and ceramic tradition. It thus becomes relevant to look at the rate of reproduction, that is the relative speed at which ceramic vessels can be produced, to determine whether Tell el-Yahudiya juglets can be seen as a separate

‘ware’; in similar manner it can be useful to take into account the reproduction rate of animals to see if they constitute an actual ‘species’ (Grant and Grant 2008). Although it can be hard to determine in archaeology, it is important to understand the frequency with which these juglets might have been produced – if we are to approach the previous question. In other words, should we see the Yahudiya juglets as rare ‘mutations’ in an otherwise fashioned juglet production, or do they constitute a substantial quantity of pottery production that had its own consistency in transmission and production? There is reason to believe that both situations can be found within the Middle Bronze Age, as will be addressed in the following sections.

4.2: The history of the study of Tell el-Yahudiya Ware: a synopsis

The history of study of Tell el-Yahudiya ware has most recently been summarized by David Aston (Aston 2008; Aston and Bietak 2012, 25-49). These studies clearly illustrate the cumulative nature of the definition with the accretion of types of ‘Tell el-Yahudiya ware.’ All of these researchers have built upon previous work and expanded and amended the knowledge on the ware. As the history of research into this category of vessels has been described in detail in the reports mentioned above, I will not repeat this here but will focus upon a couple of developments which can be seen as essential for the present study, and reflect on key issues it tries to address.

4.2.1: Early stages: recognized as a separate ware

The development of a typology of Tell el-Yahudiya ware should be seen as an accumulative process which developed with a constantly increasing corpus due to new excavations and finds. Looking through an evolutionary lens, the expanding base of knowledge about the corpus of vessels might be seen as a process of ‘descent with modification’ in itself, and would apply to a lot of archaeological knowledge frameworks.

The early emphasis was very much on establishing a basic timeline for the development, mapping the extent of the spread of the ware, and tracing its origins. Junker and Reisner were among the first to attempt a typology based on the morphology of the ceramics and decorative and technical characters of the different types (Junker 1921, 26; Reisner 1923). At this early stage, the issue of origin was hotly debated; whereas Junker saw an origin in Nubia, Reisner argued for an Egyptian origin (Junker 1921, 23; Reisner 1923; Aston and Bietak 2012).

The technical characteristics were taken into account to form groups of vessels. Nevertheless, the technical process of creating these characteristics, and what the changes might have signified, did not form part of a theoretical framework. Nonetheless, Reisner talks about ‘sets of potters’ responsible for the variation in the Tell el-Yahudiya juglets. Significantly, he introduces two concepts of transmission, with the first case being direct transmission of ‘knowledge’ between these sets of potters living in close temporal and spatial proximity, in order to account for the exact reproduction (Reisner 1923; Aston and Bietak 2012, 28). The other possibility Reisner suggests is that pottery itself was imitated by another set of potters, thus hypothesizing the transmission of knowledge to run through the artefact itself. In this straightforward way, Reisner was perspicacious in that he actually discussed the difference between vertical and horizontal transmission of knowledge, and the difference in *agency* between the potter and the artefact in the transmission of ceramic traits (see §2.5).

4.2.2: Origins and ethnic identification: the Hyksos

Subsequent studies saw authors debating the origin of this decorated ware and suggestions were for the place of origin to lie in the Near East (Syria-Palestine), and the ware being subsequently introduced (by the Hyksos) into Egypt (Bonnet 1924; Dussaud 1928; Otto 1938; Aston and Bietak 2012, 28-29).

It is significant that all of the above authors included a range of juglets that comprised decorative techniques such as painting and pattern burnishing together with the indented and white filled decoration. The fact that the corpus of Tell el-Yahudiya ware as defined at this stage was more inclusive than that used in later studies can be attributed foremost to the number of juglets found, as the corpus of known vessels increased, so did the tendency to split of ‘types’ and ‘wares’. We might wonder what this says about the practice of ceramic typology.

As Aston and Bietak suggest, Tell el-Yahudiya ware became associated ethnically with the Hyksos early on, following Engberg, and so the spread of the ceramics became entrenched with the presence of foreign (Hyksos) elements in Egypt (Aston and Bietak 2012, 32; referring to Engberg 1939; later repeated by Van Seters 1966). The so-called ‘Hyksos’ were literally ‘rulers of foreign countries’ (*Hekau khasut*) (Bourriau 2000, 174; Bietak 2010a, 139). Our ‘historical’ perception of the Hyksos is

mostly shaped by New Kingdom sources and later Egyptian literature and they are sometimes included under a wider group of ‘asiatics’ known as *Aamu* in contemporary sources (Bourriau 2000, 174). Recent evidence is starting to shed more light on the nature of their rule in the ‘Second Intermediate Period’ (abbreviated: SIP) and the traditional ethnic identification might reflect many Egyptian biases and be an inadequate description of the people living in the Delta and the diversity of their cultural practices (Marée 2010). As Redford suggests, the image sketched by Manetho of the Hyksos as marauding Asians is largely based on later invasions by the Assyrians, Babylonians and Persians (Redford 1992, 101).⁷ Thus, it is good to remember that the Delta has a long history of being a ‘hybrid’ zone in terms of mixing ‘Egyptian’ and ‘Levantine’ cultural practices (Broodbank 2013; Bader 2013; De Vreeze 2016a).

In reaction to Engberg’s ethnic identification, Säve Söderberg argued for caution on this matter and stated that the distribution and occurrence of this ceramic ware could easily be explained by a local ceramic industry in the Levant and trade connections to Egypt before the rise of the Hyksos (Säve-Söderbergh 1951, 57; Aston and Bietak 2012, 32). Although the direct ethnic identification of Tell el-Yahudiya ware was actively debated, this equation of ceramic types and ethnic groups continues to play a significant role in Near Eastern Archaeology to the present day.

For instance, the migration of people and their ceramic technology is discussed in relation to both the preceding Early Bronze Age and the later early Iron Age; through discussions on ‘Khirbet Kerak ware’ and its ultimately Caucasian origin, and ‘Philistine ware’ of the Early Iron Age connected with Aegean migrants, but needs detailed technical, contextual and theoretical approaches (Greenberg 2014; Greenberg and Goren 2009; Iserlis 2009; Philip 1999; Yasur-Landau 2010; Ben-Dor Evian 2012). In the latter case (Philistines), the debate on the identification of ethnic groups and their ceramics can be seen as near identical to the ‘Hyksos’ case and we could draw a parallel between the archaeological theory on both groups through history. Both in the Hyksos and Philistine case, the ethnic identification is based on (later) literary ethnic identifications by another group (Egyptian sources in the case of the

⁷ Nevertheless, the Mediterranean seems to have repeating episodes associated with war, economic upheaval and mass migration, attested at the end of the Late Bronze Age, and perhaps not that dissimilar from events in recent years. Such events yield starkly different perspectives depending on the economic, social and cultural position one is in.

Hyksos, and the Old Testament in the case of the Philistines). And in both cases, material culture is then taken by archaeologists to represent these implicitly ‘homogeneous’ ethnic groups. It seems undervalued that these groups emerged within a highly mixed cultural setting. These groups were perhaps looking for a unifying identity in which the perception of the other; and the other’s perception of them might have influenced this process, yet these perceptions might be far from the same. In the Philistine case, the ceramics display a combination of decorative motifs with Aegean, Egyptian and Levantine influences, and motifs such as lotus flowers and birds play an important role. It is interesting to see that many of these elements and motifs were present in the hybrid cultural style of decoration in the early Tell el-Yahudiya ware as well (see §4.13).

With a *longue durée* perspective encompassing the second and first millennia BC and beyond, it seems that within this particular geographical area (Southern Levantine coast/Shephela, Egyptian Delta), these stylistic motifs resurface in a cultural mix at different times within different ‘wares’.⁸ With retrospective lens of another later cultural group (itself not homogeneous either), these cultural mixes are then ethnically branded, such as the view of the invading Hyksos by ‘Egyptians’ in the New Kingdom. In the study of Tell el-Yahudiya ware, though more nuanced than before, ethnicity is still an important element. The formation of group identity might very well have a significant role in the adaptation and use of certain ceramic vessels. The fact that ceramic styles in particular are still seen (by some) as representing ethnic groups directly originates from the lack of archaeological theory on what a ceramic style represents as well as how ethnicity is constituted (see for instance Bader 2013; Jones 1997; Redmount 1995). The fluidity and nuances of the concept of ethnicity should be equalled by the fluidity in which we can think about the transmission of ceramic knowledge (§2.4.9).

The connection of the Tell el-Yahudiya vessels in Egypt and those found at sites on Cyprus was early on identified by Paul Åström, who further developed the typology of the ware on the basis of examples from Cyprus, Egypt and the Levant in his dissertation on Middle Bronze Age Cypriote ceramics (Åström 1972, 32-33; Aston and Bietak 2012; Åström 1957). This Cypriote connection became more important in

⁸ Which makes one wonder if they were continuously be used on perishable media such as textiles (see now Wilkinson 2014a).

later discussion on the distribution and trade connections as later studies showed that most of the Cypriote Tell el-Yahudiya juglets were actually produced in Egypt (see work on Kaplan below).

It is interesting to see that throughout the history of research, authors suggest a key role for the specific geographic area they work in. Like the earlier ‘Nubian’ connection, so Ruth Amiran voiced the crucial part Palestine played in the part of the development of Tell el-Yahudiya ware (Amiran 1969, 35; Aston and Bietak 2012). When discussing the development of features in Tell el-Yahudiya ware, such as a change from more ovoid body shapes into piriform vessels, Amiran significantly uses verbs and words such as ‘evolving’, ‘degenerating’, and ‘descendent’ (Amiran 1969, 119). She sketches out developments starting in the Middle Bronze Age I (her Middle Bronze IIA) pertaining to the body shapes, rim shapes, and decoration which very much foreshadow later conclusions by other authors and still seem to hold true (Amiran 1969, 120). Moreover, Amiran was the first to note the significance of the pottery workshop at ‘Afula (in present day northern Israel), where unfired and fired examples of juglets decorated in the Tell el-Yahudiya style were found. This group of vessels from ‘Afula has become the quintessential ‘prototype’ in Tell el-Yahudiya ware studies although, the production site not published until some time later (Zevulun 1990).

4.2.3: Middle Bronze I Middle Kingdom traditions: Merrillees and his ‘Lisht ware’

Robert Merrillees followed the well attested archaeological tradition of naming an artefact type after the place where a considerable number of vessels have been found. He coined the term ‘Lisht’, after the Middle Kingdom Pyramid complex at el-Lisht, south of modern Cairo, to describe what he believed to be the earlier stage of Tell el-Yahudiya ware (Merrillees 1974; Merrillees 1978). The attribution of juglets to this early ‘el Lisht’ stage were based on the larger size of these vessels, their general finer walls, the vessel shape, characteristic rims, multi-stranded handles and elaborate motifs and schemes of decoration (Merrillees 1978, 73; Aston and Bietak 2012, 38; see **Fig. 4.1**). In a similar vein to Amiran’s work Merrillees uses ‘evolution’ to describe developments in Tell el-Yahudiya ware; though again, the mechanisms for these are not fully specified (Merrillees 1978). However, Merrillees does refer to possible different contemporaneous developments taking place within geographically separated regions such as the Northern and Southern Levant and Egypt, an idea which

is significant as it moves away from ideas of development as linear evolutionary progression (Merrillees 1978, 91-92).

4.2.4: Systematic classification and chemical analysis

Thus far, the debate on the origin and location of fabrication for the different attested styles of Tell el-Yahudiya ware had been based on a growing corpus of finds from the Near East, but had not been tested by examining the fabric of the juglets in greater detail. This changed with a study by Maureen Kaplan specifically targeting this issue (Kaplan 1980; Kaplan *et al.* 1982). She offered what was then the most complete and comprehensive treatment of Tell el-Yahudiya ware by collecting as many examples as possible from publications and in museum collections and subsequently testing these samples using Neutron Activation Analysis to get a better picture of their provenance (Kaplan 1980, 3-4). This has yielded the most complete record of Tell el-Yahudiya ware — until Aston and Bietak's recent publication (2012) — and remains a popular reference. This work merits slightly fuller attention in this overview.

Kaplan starts out by working out a more rigid typology of Tell el-Yahudiya then previously conceived and makes use of cluster analysis to define the general shape of vessels (Kaplan 1980, 5-39; 216: Chart 1). In the end she uses three proportions to define the groups 1) neck height in relation to overall vessel height, 2) maximum width in relation to overall vessel height, and 3) the position on the body where the maximum diameter occurs (measured from the base up (Kaplan 1980, 6). By using measurement proportions, the size becomes a relative factor, and thus vessels of different size can belong to the same general shape group. Unfortunately, the mathematical definitions of her clusters are almost completely omitted in the text, moreover, as Aston and Bietak also attest (2012a, 58), she subsequently does not stick to her rigid cluster analysis in describing the various groups. Importantly, Kaplan remarks that these proportions are continuous data, which also has consequences if we want to use them as coded characters (Kaplan 1980, 7). Other information on the handle, rim and base as well as decoration was seen as discrete variables (Kaplan 1980, 8). This is very much in line with the way categorical variables which are used by Aston and Bietak have defined groups of Tell el-Yahudiya juglets, with the important note that these characters are defined verbally (such as 'gutter rim', 'ring-base') but not quantifiably. Kaplan subsequently combined the information on these characteristics in her definition of groups. Unfortunately, these definitions of her

vessel groups are missing in a clear overview, although separate data is mentioned throughout the text (Kaplan 1980, 18-39). As Kaplan indicates herself, her cluster analysis based on the three proportions (see above) yielded a problem where it grouped vessels of different overall morphology but sharing similar proportions (Kaplan 1980, 14: Fig. 2). Nevertheless, except for a mixed group, the cluster analysis yielded five main groups defined by Kaplan as: 1) ovoid, 2) biconical, 3) piriform, 4) globular, 5) cylindrical. Subdivisions in these groups were made on the basis of the other (discrete) characters. Separate groups were made on the basis of their unique shape (ichtyomorphic, bird-shaped, quadrilobal). The basic groups can be summarized as follows (**Table 4.1**).

Shape	Type	N/H: W/H: PMD	L range (cm)	Form of Base	Form of Rim	Form of Handle	Decoration	Reference Kaplan 1980
Cylindrical	1	Extremely low PMD	7.6-12.6 Av. 9.05	Rounded	Rolled over or slightly everted	Single strand	Vertical plane: chevrons or row of punctures	Kaplan 1980, 16-17
	2		9.7 to 15.4 Av. 13.3	rounded to flat	rolled over or slightly everted rims	double stranded	one or two bands of chevrons which cover only a fraction of the entire body	
Globular		N:H: .305 (.215-.375), W:H: .650 (.564-.753), PMD: .425 (.334-.563)		rounded	rolled over, though some straight and slightly everted rims	single strand	Bands with herring-bone decoration	Kaplan 1980, 17
Quadri-lobal				Rounded	Rolled over rims	Single strand		Kaplan 1980, 18
Piriform	1	N:H: .288 (.206-.364), W:H: .566 (.461-.648), PMD: 7.30 (.690-.777)	12. cm av and 15.8 cm av.	ring to indented button	Un-usually inverted (everted occur as well)	almost always multiple stranded. Double most common	often burnished all over. Three to four bands filled with triangles and rectangles, three bands of rectangles,	Kaplan 1980, 19

							two bands of standing and pendant triangles	
Piriform	2a		7.2-13.3. av. 10.4	ring or button	rolled over rim	single strand	three or four gores filled with herringbone pattern of incised dots	Kaplan 1980, 21
	2b	N:H: .254 (.225-.287), W:H: .641 (.592-.685), PMD: .719 (.697-.723)	10.1-13. av. 11.3	pronounced button base	drawn up and trimmed, or rolled over and pressed thin	always double	Similar to 2a	Kaplan 1980, 22
	3	N:H: .246 (.203-.297) smaller vessels.213 (.171-240) larger vessels,	11-13; 14.6-17.5, av. 12 and 15.9		drawn up and rolled over		Horizontally orientated and covers less than half the available body	Kaplan 1980, 23
Biconical	1		7.8-16.0, av. 10.5	button base	always rolled over	single strand	covers most of the body, leaving only a narrow burnished band around the girth of the vessel	Kaplan 1980, 24
	2					Narrower rim	two narrow bands of decoration	Kaplan 1980, 25
Ovoid	1		Large		drawn up straight and everted		to or three narrow delineated bands of straight or oblique lines	Kaplan 1980, 26
	2			button base usually smaller and thinner. Define 'narrow flat' 'small button'	never rolled over: inverted to straight to slightly everted	rarely single, usually double. Triple also exist	several bands of oblique lines or dots. Horizontal bands might also be filled with triangles, chevrons or,	Kaplan 1980, 27

							in one case, circles. Vertical oriented decoration (Afula)	
	3	Sharp angle between shoulder and body					Black slip added (imitating reduced firing).	Kaplan 1980, 27
	4	Slightly, wider, PMD lower		ring or button	inverted rim	triple stranded	four horizontal zones. Both standing and pendant triangles in the same row	Kaplan 1980, 28
	5						use of circles and spirals	Kaplan 1980, 28
Miniature			Av. 6.5 cm	button base			varying	Kaplan 1980, 28
Grooved					rolled over rims	single strand		Kaplan 1980, 29
Bird shaped	Vessels formed in shape bird							Kaplan 1980, 29
Ichty-omorph	Vessels formed in shape bird							Kaplan 1980, 32
Natural-istic designs							Design incorporating flora and fauna.	Kaplan 1980, 32

Table 4.1: Kaplan's groups with her published defining characters and the measurements (PMD stands for position of the body where the maximum diameter occurs) N:H stands for the ratio of the neck vs. the height (L) of the vessel, W:H stand for the ratio of the maximum width versus the height of the vessel, as given in the (after Kaplan 1980).

In her choice of groups, Kaplan sometimes gave priority to decoration (as in 'Grooved Ware', and vessels with 'naturalistic designs' (Kaplan 1980, 29; 33, see table 4.1). Such inconsistency is problematic since these vessel groups yield similar body shapes and other characteristics in rim, handle and base shape. This problem has persisted in the division of the Tell el-Yahudiya into types, and is present in subsequent treatises, including the most recent by Aston and Bietak (2012) as well (see below).

Subsequently, Kaplan established the geographical range of her groups, and used neutron activation analysis to further define regional groups (Kaplan 1980, 47-66).

4.2.5: Early Provenance studies of Tell el-Yahudiya ware

Two early studies showed that Neutron Activation Analysis was able to distinguish production areas for Tell el-Yahudiya ware. Artzy and Asaro (1979) showed the dominance of Egyptian imports among the Tell el-Yahudiya juglets found on Cyprus. Maureen Kaplan subsequently extended this methodology studying 155 selected samples from different locations (Kaplan 1980; Kaplan *et al.* 1982). Her control group was a reference collections of ceramics from the region and clay samples previously stored at the Brookhaven National Laboratory (Kaplan 1980; Kaplan *et al.* 1982). Kaplan concludes that there are two main traditions: The 'Palestinian' tradition with 'Limestone Hill' and 'Red Field clay' as chemical characteristics (but see below), and the Egyptian tradition produced in Egypt: 'Nile alluvium', 'Nile mixture', 'Pleistocene' 'Aswan' and 'Sudan' (Kaplan 1980, 227-228: Table 3). The latter, as previously suggested, were exported elsewhere, in particular to Cyprus. She concluded that the types produced in Syria-Palestine were more geographically restricted and belonged to the 'Ras Shamra' (Ugarit), 'Red Field' and 'Limestone Hill' groups (Kaplan 1980, 227-228: Table 3). According to her analysis, these vessels were rarely exported outside of their geographical region, with a notable exception of a single juglet at Tell el-Dab'a (Kaplan 1980, 66). In the end, Kaplan understands the corpus of vessels to consist of two 'families', Egyptian and Levantine (Kaplan 1980, 122). Unfortunately, she drew an erroneous conclusion regarding the origin of the initial phase of production of these vessels, partly based on inferences about the absence of techniques used in Tell el-Yahudiya ware in the Levant, and on disputable chronological foundations (Kaplan 1980, 74). Kaplan suggests that the origin of Tell el-Yahudiya ware might very well lie in Egypt (Kaplan 1980, 122). Her basic conclusion of different 'families' (or traditions) existing in Egypt and the Levant was however corroborated by later research.

4.2.6: Recent provenance studies

More recent studies using both petrography and NAA have added substantial nuance to Kaplan's earlier conclusions and offer sharp critique of her results (Goren and Zuckermann 2002; Cohen-Weinberger 2008; 2011). The main chemical groups of

‘Limestone Hill’ and ‘Red field clay’ can be equated with the petrographic groups of ‘Moza formation of the Central Hill Country’ and ‘loess soil from the northern Negev’ (Goren and Zuckermann 2002, 442).⁹ Anat Cohen-Weinberger has conducted a number of studies including of Tell el-Yahudiya ware, foremost her unpublished PhD, and suggests that Kaplan’s groupings of ‘Limestone Hill’ and ‘Red Field’ are too broadly defined, partly overlap in terms of petrography, and do not account for a larger number of production locations (Cohen-Weinberger 2008; Goren and Zuckermann 2002; Cohen-Weinberger 2011). On the basis of an extensive number of petrographic samples (193 in her thesis), along with other Middle Bronze Age vessels, Cohen-Weinberger shows that important nuances exist in Kaplan’s two rough groups, and the ‘Palestinian’ type juglets were actually produced in a number of regional workshops (Cohen-Weinberger 2008; Cohen-Weinberger and Goren 2004). Perhaps most significant, Cohen-Weinberger distinguishes a particular petrographic signature (Group B) pointing to the Northern Levant (Lebanese coast) suggesting a distinct production location (or number of locations) in this area (Cohen-Weinberger 2008; Goren 2002, 442).

These results will be addressed in more detail below as they form a key assemblage of vessels (Merillees ‘Lisht ware’; Aston’s groups I, J). Subsequent petrographic studies on vessels from excavations at Fadous-Kfarabida and Tell Arqa by Kamal Badreshany and Mary Ownby corroborate the local North-Levantine (Lebanese) production of some Tell el-Yahudiya ware (Genz *et al.* 2010; Charaf and Ownby 2012). Maier analysed 5 examples of Tell el-Yahudiya ware from Beth-Shan and concludes that at least one of the juglets (Kaplan’s piriform 3, (Aston type L1.2 see below) is of clear Egyptian production (Maier and Yellin 2007; Maier 2012, 585, 588). A bird shaped vessel might have been imported from Egypt but has not been analysed (Maier 2012). The piriform Egyptian import is interesting as it helps support the idea of Beth Shan as a key gateway city providing trade access to the middle Jordan Valley (Maier 2010). However, the majority of the Tell el-Yahudiya vessels (6) from Beth Shan seems to represent southern Levantine production (Maier 2012: Fig. 6). This is significant as the limited number of Tell el-Yahudiya vessels from the Jordan Valley and Transjordan plateau (at Pella, Abu Kharaz (single sherd), Tell es-

⁹ The petrographic groups (and their nomenclature) defined by Yuval Goren and his team are over-closely linked to geology of Israel, and their analysis does not take full account of the existence of similar geological deposits in neighbouring regions, such as Jordan and Lebanon.

Sa'idiyeh (single sherd), Tell Deir 'Alla (single sherd), Tell Hammam, Amman and Mount Nebo; see below) have unfortunately not been examined petrographically but predominantly show characteristics related to juglets produced in the Southern Levant, and can be suggested to have been produced in the area (contra Bourke *et al.* 2006, 49: Suggesting the vessels at Pella to be of 'foreign' origin).

4.2.7: Tell el-Dab'a fabrics

The dataset from Tell el-Dab'a offered by (Aston and Bietak 2012) incorporates consistent basic information on the fabrics as defined according to the standardized fabric system used at the site (Aston and Bietak 2012; Aston 2004; Bietak 1991b). However, fabric descriptions of complete vessels might rely on assumptions, since the break could not be observed (Aston 2004, 44). Using these fabrics for statistical measures might therefore be problematic but might be assumed correct for general overview. However, the distinction between Levantine (non-local IV) fabrics and local (I-b-2 and I-d) fabrics seems strong enough to be of use. I-b-2 and I-d can be assumed to relate to local production. Perhaps interestingly, Bietak (1991b: 326) has suggested fabric I-d to be a local adaptation to clay in imitation of the clays used in the Northern Levant. A possible reason for this imitation meriting further study would be to create lean clay suitable for throwing on the wheel.¹⁰

4.2.8: The Tell el-Dab'a excavations and their impact

Kaplan's work was extensive and brought together an enormous amount of information on Tell el-Yahudiya ware, yet it overlooked the importance of a very crucial site and influence on the development of this ware. Tell el-Dab'a plays a relatively minor role in Kaplan's work, this because she did not have access to much of the material directly, which at that point had been published scantily (preliminary reports) at the time she wrote her thesis, and because hardly any direct chemical analysis was done on Tell el-Dab'a vessels (Kaplan 1980, 229-234, only an ovoid jar from Dab'a turned out to be 'Red Field'). Moreover, her chemical 'Nile clay' or 'Nile-mixture' groups are not fine-grained enough to identify specific locations of fabrication within a single site, which as I will argue, should point at Tell el-Dab'a as a dominant production area.

¹⁰ The petrographic signatures of these clays and their workability would be worthwhile testing in future studies.

Tell el-Dabʿa is crucial in our understanding of the evolution of Tell el-Yahudiya ware. The site has been excavated since 1966 under the directorship of Manfred Bietak, and had yielded a corpus of 699 vessels and fragments up to 2011 (Aston and Bietak 2012). This site is believed to be the Hyksos capital of Avaris in the Second Intermediate Period, which is conventionally dated to 1750-1550 BC (but see below §4.3.5 on recent debates the chronology). The settlement started as a small 15-25 ha harbour town in the eastern Delta, on the Pelusiac branch of the Nile, which connected it to the vast trading potential of the Mediterranean (Bietak 2010a, 140; Bietak 2010b, 11). As such its position was anchored between the Near East and the Mediterranean to the north and Middle and Upper Egypt to the south. This position turned out to be crucial, as in subsequent decennia, the small Middle Kingdom harbour town grew like a spider in an international web feeding on cultural connections and trade, first as a sizeable town in the Late Middle Kingdom (75 ha) and in the early Hyksos period it became the largest site in the Eastern Mediterranean with an estimated size over 250 ha (Bietak 2010b, 11: though unknown is if all of the area was simultaneously occupied).

Manfred Bietak published two specific articles on Tell el-Yahudiya ware (Bietak 1985; Bietak 1989a). In these, he builds on Kaplan's work but offers important additional suggestions foremost based on the excavations at Tell el-Dabʿa. Moreover, he suggests that the origin of the ware is clearly to be sought in the Southern Levant, from where it spread geographically, and formed separate traditions in Syria-Palestine and Egypt (following Kaplan), he summarized this idea in a tree schedule in which evolution is implicit and that is actually quite similar to a cladogram (Bietak 1985; Aston and Bietak 2012, 52: Fig. 9, 53: Fig. 10; see **Fig. 4.3-4**).

Building on the work of Bietak and Kaplan, David Aston (in close cooperation with Manfred Bietak) extended the typology of Tell el-Yahudiya ware, making use of the increasing corpus from Tell el-Dabʿa and new finds from the Levant (Aston and Bietak 2012). Moreover, their record of the vessels, with well published detailed drawings and descriptions is a crucial resource for this case study. However, the neat position of the ceramics into the separate phases of Tell el-Dabʿa has recently been scrutinized, and suggested to ignore questions such as residuality (Warburton 2009a). Importantly, there might be an issue of 'circular reasoning' incorporated in the processing of ceramics at Tell el-Dabʿa, where phases are dated by ceramics, and

ceramics are dated by phase, specifically relating to grave assemblages. For instance, doubt may be cast on the fact that phase E/2 has any stratigraphic reality.¹¹ We will discuss the issue of chronology in more depth later.

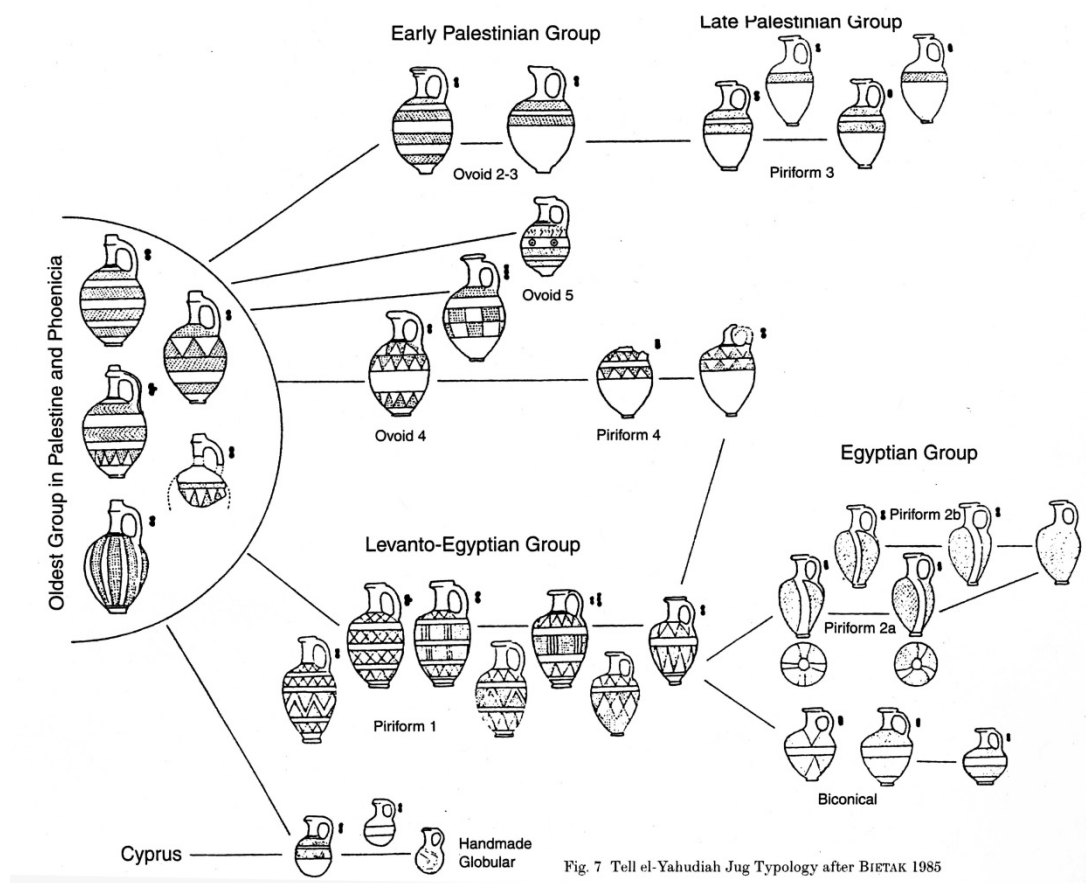


Fig. 4.3: Tree diagram of Tell el-Yahudiya ware, development reminiscent of a phylogeny (after Bietak 1985; Aston 2008, 187: Fig.7).

Aston and Bietak devised a system of ‘branching’ to describe the various groups of Tell el-Yahudiya ware. The terminology of ‘branches’ and presentation of the groups into a tree-like schedule is reminiscent of evolution and an implicit reference to this framework (Aston and Bietak 2012: Fig. 9, 53: Fig. 10: see Fig. 2-3). The authors suggest the main branches to represent ‘genetic mainstreams in development’ and the subsequent branches to represent consistent groups that lie outside of the

¹¹ David Aston acknowledged in personal communication that phase E/2 does not exist stratigraphically but only as a ‘ceramic phase’, yet 42 Tell el-Yahudiya vessels from 7 architectural loci and 12 distinct graves are attributed to this phase.

mainstream development (Aston and Bietak 2012, 58). Significantly, using this terminology, the authors hint at biological principles of genetics and heritable consistency. The mainstream branches are represented by the capital letters A-F, H, I, K and L. The outlying groups that form consistency are branches G-J, M and Q. However, key identifiers, such as particular fabrics, do not play the role in this discussion to the extent that they will have to. We will treat these groups in more detail below in our first cast study.

The vessel typology is largely based on Kaplan's defined shapes (Aston 2004, 44). In general, the shape definitions are retained, but the types and numeral subdivisions are more detailed based on the variety of vessels attested at Tell el-Dab'a. In their volume, the branches are further subdivided with numerals and small letters (such as Branch B.1.2.a). These subdivisions are along the lines of general vessel shape, morphological characters, and decorative patterns. The level of variation is generally from vessel shape (B.1 = B.2 =) to smaller variations in base (X.X.a = , X.X.b =). Without explicitly stating so, the different characters are thus hierarchically organized. This has important implicit implications, and would benefit from more thorough theoretical underpinning.

4.3: The Dataset

4.3.1: The assemblage

The assemblage used for the our case study consists of the published record of Tell el-Yahudiya ware collected in Kaplan's work and augmented and extended by the Tell el-Dab'a publication (Kaplan 1980; Aston and Bietak 2012). Vessels omitted in these studies and more recent discoveries are included for comparison, mostly fitting pre-existing 'types' but giving new information on distribution. An unpublished PhD (Cohen-Weinberger 2008) on petrography and NAA analysis incorporating a wide range of previously published and unpublished data adds important new information from the Levant, particularly on locations of production (see §4.2.6). The analysis in this thesis is solely based on these published records. While this might be seen as a weakness, it is taken as a pragmatic and deliberate approach, one in which the analysis and its results and shortcomings will reflect on the discipline's general approach to the collection of data, and the way in which ceramic evidence is presented in archaeological publications.

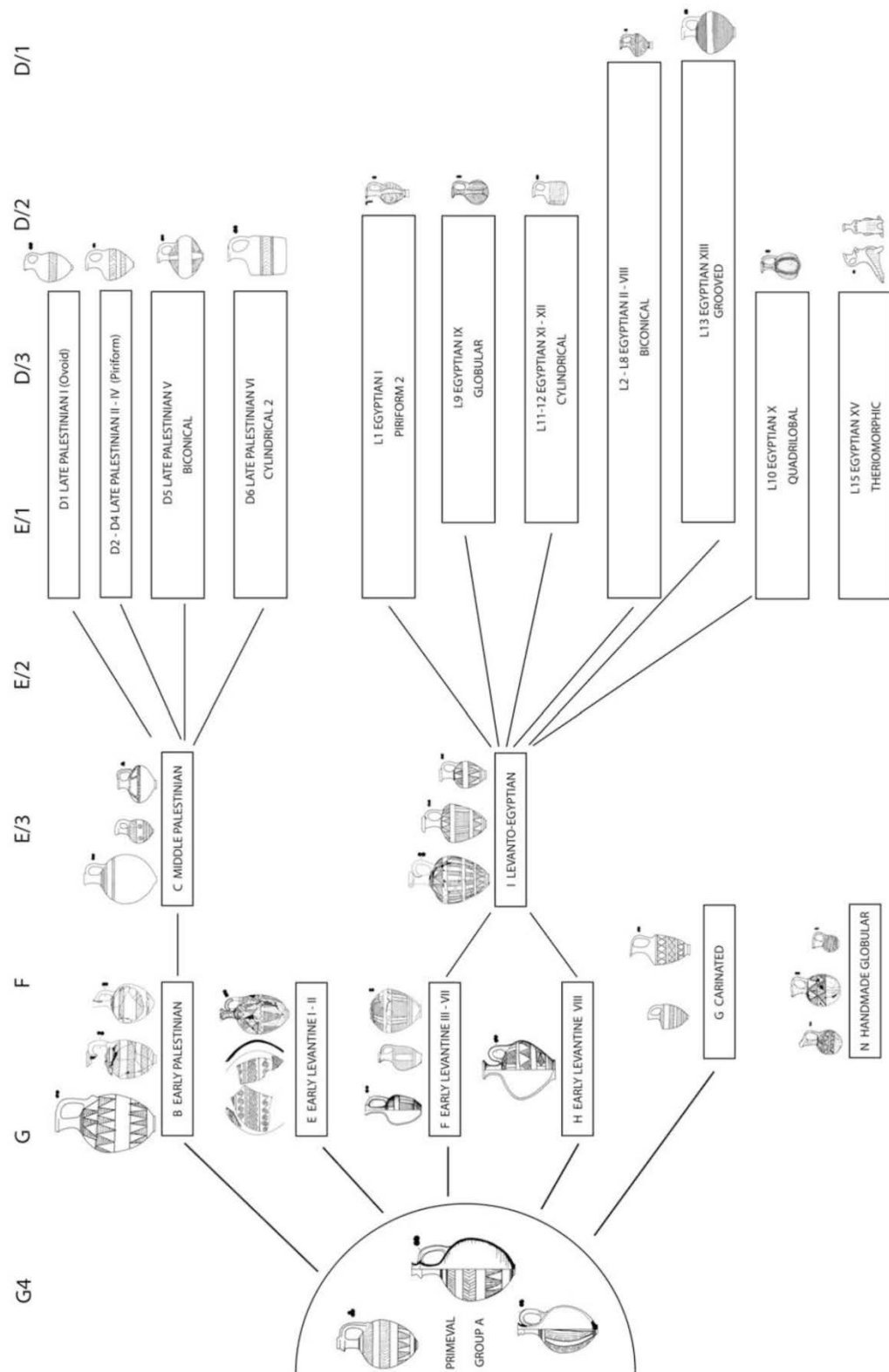


Fig. 10 Tell el-Yahudiya Typology after Bietak and Aston 2010

Fig. 4.4: More recent diagram of Tell el-Yahudiya development based on new insights (after Aston and Bietak 2012, 52: Fig. 9, 53: Fig. 10).

I firmly believe that new information can be generated from old sources, and that if it is in any way useful, the published record should permit new conclusions to be drawn.

The quality of information differs considerably, although Kaplan was fairly rigid in her explanations, information is often lacking on technical features which might give real insight into the technological decisions of the potter and the drawings are fairly crude. The drawings seem to be standardized in a way that obscures much information (such as the profile on the side with the handle, which prohibits a good profile of the rim shape), and often the drawings seem simply to copy previously published drawings of the vessels so not too much detail can be read into them. They thus offer a basic level of inquiry. The dataset published by Aston and Bietak is of much better quality, with technical features often shown in drawings (from different sides) and measurements and characteristics on finishing techniques mentioned in the database.

The assemblage used consists of 1315 vessels (116 of unknown provenance) (including fragments) of which 592 are complete (full profile and suite of separate characters such as base, handle, rim). Most of these vessels are collected in the work of Kaplan (1980), but more recent excavations have yielded new examples from Jordan, Lebanon and the southern Levant. Significant is the before mentioned this by Anat Cohen-Weinberger with petrographic and NAA samples taken from a large group of published and as yet unpublished Tell el-Yahudiya juglets, the basic information of which is incorporated in my database. Most significant is the full assemblage of Tell el-Yahudiya vessels from Tell el-Dab'a in the recent volume by (Aston and Bietak 2012). Moreover new vessels from Ashkelon, Arqa and Beth Shan are also published in this volume (Charaf and Ownby 2012; Maier and Mullins 2012; Stager and Voss 2012).

The database with information used in this thesis builds on Kaplan's work and Tell el-Dab'a's 699 vessels and fragments. It is expanded by recent finds and neglected vessels not found in the two sources. Important to note is that the assemblage is still growing; for instance with yet to be published assemblages in Lebanon (Charraf 2014), with new finds being added, and more vessels being published in republications of old excavations. Out of this assemblage, 699 vessels and fragments derive from Tell el-Dab'a as published by Aston and Bietak (2012)

which form almost half of the total assemblage, thus showing why Kaplan's data was skewed and stressing the importance of understanding the dynamics of Tell el-Yahudiya ware at this site. As will be argued in this chapter, the evolution of Tell el-Yahudiya ware cannot be properly understood without understanding the dynamics at this site.

The assemblage, though still increasing, yields a number of fairly well established groups (new finds often falling within these groups), of which the characteristics and geographical range have been set out by previous authors and culminated in the work of Kaplan, Aston and Bietak. Nevertheless, key lacunae remain such as southern Syria and an increasing number of examples from Lebanon (Charaf 2014; Maqdissi *et al* 2002).

4.3.2: The Context of Tell el-Yahudiya vessels

What is important to note is that interest in the role of these juglets and their context in the archaeological record has been subdued by concerns about chronology and general patterns. This is not only true for the earlier accounts; even Maureen Kaplan (1980) treats the context of the juglets mostly from a chronological standpoint, to provide information on the relative chronology. The most recent volume by Aston and Bietak (2012: 557-558), albeit being very complete and detailed in approach, only treats the role of the juglets in socio-cultural terms in a minor paragraph. Moreover, while the archaeological context of each juglet is given in the volume, the funerary areas at Tell el-Dab'a are described in separate volumes on the excavations at the site, and as such, the development of the juglets is somewhat torn away from their archaeological context. This fact, although not uncommon in archaeological publications, and perhaps logical due to constraints in time and space for publishing, does have consequences for the framework in which we see the development of the juglets. As might become clear in this treatise, the evolution of Tell el-Yahudiya juglets, as goes for all artefacts, cannot be separated from the contexts in which they are found, the role of the artefacts in daily life, and perhaps most crucially the position of the potter in the interplay of supply and demand, fashion defines selective pressure in evolutionary terms (§2.3.7). The evolution of the juglets, as any artefact, can only be grasped in its full extent by studying the associated mechanisms of cultural selection; i.e. what role the vessels played, what cultural niche they filled, what significance they had?

It is thus highly significant that occurrences of these Tell el-Yahudiya juglets are by far dominated by those appearing in funerary assemblages (Kaplan 1980; Aston and Bietak 2012; Forstner-Müller and Rose 2012). Although part of this dominance might be attributed to the differences in preservation (more complete examples from funerary assemblages opposed to fragmentary remains in settlement layers) and related difference in taphonomic processes, it is unlikely that this alone can explain the sheer dominance of these vessels as grave goods.

At Tell el-Dab'a *at least* 49% of the published Tell el-Yahudiya ware vessels come from secure grave contexts (343 of 699) and a further 9.7% (68) are clearly associated with pits, usually offering pits or depots (48 from Locus 81, see discussion §4.13.2) (See **Table 4.2**). 41% of the vessels (288) come from other contexts such as temple areas, houses and include what is indicated generally as 'planum' contexts and which are stratigraphically less secure ('fill'), some of which might actually relate to funerary remains as well (Aston and Bietak 2012). Of the 616 Tell el-Yahudiya vessels from sites outside Tell el-Dab'a, 50.7% (312) derive from clear tomb contexts, whereas 13.1% (81) derive from non-tomb, 'domestic' contexts. However, it remains problematic that a large number of vessels, namely 36.2 % (223), in the database have no clearly identified context (**Table 4.3**).

With the large possibility that among the unknown contexts (and general 'planum' of Dab'a), tomb contexts in the form of unidentified, disturbed and looted graves might form a considerable number, it is clear that at least half of the Tell el-Yahudiya vessels which form part of the known assemblage are known from funerary assemblages at sites other than Tell el-Dab'a. Moreover, this number corresponds quite well with the site of Dab'a itself, where roughly half of the vessels derive from grave assemblages.

Dab'a	Tomb context	Pit (including offering pit)	Non-tomb context
#	343	68	288
%	49.1	9.7	41.2

Table 4.2: Grave versus non-grave contexts of Tell el-Yahudiya vessels (total 699) from Dab'a and other sites.

Outside of Dab ^{sa}	Tomb context	Non-tomb context	Unknown
#	312	81	223
%	50.7	13.1	36.2

Table 4.3: Tomb versus non-tomb context of Tell el-Yahudiya ware vessels (616) outside of Dab^{sa}.

Due to their general small size, the constricted necks and this dominant role in funerary assemblages, the juglets as a general group have most often been seen as containers of precious (perfumed) oils. Jill Baker has suggested juglets (including Tell el-Yahudiya ware) to be part of a ‘funeral kit’ (Baker 2006). Unfortunately, little actual analysis has been done on the content, and while the residue analysis undertaken does suggest vegetal and animal lipids, these remain somewhat inconclusive (Aston and Bietak 2012, 621). The importance of perfumes and unguents in Late Bronze Age Mediterranean exchange of commodities is stressed by Louise Steel (Steel 2013, 131-135), and we will return to the context of these juglets, the role they might have played, and the consequences for the demand for, and production of, these vessels at a later stage (this theme will be taken up in the discussion: §4.13). We only note at this stage that a study of the evolution of these juglets is incomplete without consideration of their clear association with funerary deposits, and the importance of precious oils or liquids they might have contained, as these form the causal links between production and consumption.

4.3.3: Stratigraphy and chronology, a heated debate around Tell el-Dab^{sa}

The standard stratigraphy as used in the Tell el-Dab^{sa} volumes is remarkably tight (see **Table 4.4**; **Fig. 4.5**). Phases are mostly dated within a time-span of 30 years following each other in a neat sequence (Bietak 1991a, 32: Fig. 3; Forstner-Müller 2008). It seems that the stratigraphy is mostly defined by building phases, tomb typology and seriation of artefact types (Bietak 1991b, 25; Bietak 2013, 78). Two stratigraphical numbering systems are used: in area A I, II, IV and A/V, the strata have capital letters designating the phases, and this is the stratigraphical scheme that is most dominant in subsequent literature. The phasing of area A/II forms the backdrop for the other areas and the site-wide stratigraphy by cross references of key artefact categories. In area F, small letters are used, and subsequently, the two stratigraphical sequences are joined in a single scheme (Bietak 1991a, 31, 32: Fig. 3).

This system has persisted until the present day and is still used as a reference for the stratigraphy of the site (Bietak 2013). Questions remain how building phases in different areas are connected to each other without connecting stratigraphical sequences (see Warburton 2009a for more detail). This is predominantly done on the basis of the associated artefacts, particularly pottery seriation. Yet if we subsequently date these artefacts by their stratigraphic phase, this is quite simply circular reasoning.

For purposes of convenience, I have devised a numeral system that corresponds to two numeral phasing systems used at Dab^a, in order to create a continuous numerical phasing. We must remember that this strict continuous phasing is artificial, as C-14 dates show that the Dab^a phases might actually overlap (see below) I use this numerical system in order to be able to compare juglet occurrence in contemporary phases. The scheme is simplified and shown in **Table 4.4**:

A/II	H	G/4	G/1-3		F	F- E/3	E/3	E/3- 2	E/2	E/2- E/1	E/1	E/1- D/3	D/3	D/3- 2	D/2	D/1
F/I	d/2	d/1	c	c/b3	b/3	b/3- b/2	b/2	b/2- 1	b/1		b/1- a/2		a/2			
#	1	2	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	10
Con. BC	1800- 1770	1770- 1750	1750- 1710		1710- 1650		1680- 1650		1650- 1620		1620- 1590		1590- 1560		1560- 1530	???
C ¹⁴ BC		1950- 1825	1880- 1800		1885- 1775		1830- 1745		1775-		-1710		1740- 1680		1730- 1660	1720- 1640

Table 4.4: Shows the chronological phasing of Tell el-Dab^a with a continuous numerical phasing that incorporates the two existing stratigraphical schemes. Con = Conventional dates (presently used at Dab^a) are published, as well as dates more in line with the C¹⁴ date ranges (by approximation see below).

The graves from areas A/II and F/I, attested to be linked to the stratigraphy and containing the bulk of the juglets, are either associated with the presence of a sequence of temple complexes (phases F-E/2) or houses in more tightly packed settlements (phase E/1; mostly D/3-2) (Bietak 1991b, 25; Forstner-Müller 2008;

Forstner-Müller 2010). Might we thus ask if the stratigraphic phasing is partly a difference in spatial and social stratigraphy?

4.3.4: Tell el-Dabʿa and the debate on the synchronization of East Mediterranean chronology

The phasing of Tell el-Dabʿa has been an ongoing debate in Near Eastern Archaeology, as it is related to the ‘high’ and ‘low’ chronology for the 2nd millennium BC (for further references, see: Dever 1992; Weinstein 1992; Wiener 2006). William Dever already offered a significant critique of Bietak’s dating of the stratigraphy of Tell el-Dabʿa suggesting it was too recent on the basis of the correlation with the Southern Levantine material sequence and obscures the fact that material culture would suggest a ‘peaceful’ Levantine presence at the site far ahead of the turmoil connected to the Hyksos and the Second Intermediate Period (Dever 1992, 5-8). This debate has not been solved and either ‘high’ (preferring a date of the 12th Dynasty and Phases H and G close to 2000 BC) or ‘low’ (phases H and G closer to 1850 BC) are still used in archaeological literature with the excavators of Tell el-Dabʿa holding on to the original low chronology.

Yet recently, the debate has come to a virtual stand-off with the onset of absolute dates showing a consistent offset of around 100-120 years in the dating offered for the phases by Bietak, and the C-14 dates of both the site and contemporary dates from the Eastern Mediterranean. This shift is highly relevant for the debate concerning the historical narrative entwined with the stratigraphical sequence at Dabʿa and the wider Eastern Mediterranean, as Tell el-Dabʿa has become an anchor point in the attempt to fix the Mediterranean, Mesopotamian and Egyptian chronology (Bietak 2000; Bietak 2003; Bietak 2007; Wiener 2006; Warburton 2009b).

One of the crucial anchors in this debate is the eruption of the Thera at Santorini and discussions about the dating of this event (Warburton 2009b; Cherubini *et al.* 2014; Manning 2014; Manning *et al.* 2014). Dates for the eruption are either placed around 1500 BC (low chronology), or is placed at the end of the 17th century, with increasing support for the date around 1630-1600 cal BC. (Manning *et al.* 2014) In a volume on the Thera eruption, Warburton has offered considerable critique on the stratigraphy and neat attribution of ceramics by phase, and has raised the question if the stratigraphy of Tell el-Dabʿa can be taken at face value (Warburton 2009a).

Moreover, ongoing research on radiocarbon dates from the Eastern Mediterranean suggest that the absolute Mediterranean and Egyptian chronology is fairly well resolved *except* for Tell el-Dabʿa with a low chronology which seems to be ‘off’ consistently with a 100-120 years (Manning and Kromer 2011; Bronk Ramsey 2010). A recent study using Bayesian methods examined the chronology for Egyptian Dynasties and found good consistency, with a lacunae for the SIP (Bronk Ramsey 2010; Shortland and Bronk Ramsey 2013). The discrepancy in dates for Dabʿa is still a matter of debate, with one camp looking for answers in a regional (exceptionally local) offset (Bietak 2013). Tell el-Yahudiya ware plays a role in the debate, for instance its presence in tombs in northern Cyprus is used by Bietak (2014: 281) to support a low chronology (and date around 1500 BC for the Thera eruption). The problem is that the contextual date of these vessels on Cyprus, from tombs yielding no absolute dates, cannot be verified independently, and become part of a circular argument in relative dating.

4.3.5: The fundamental problem of dating the Dabʿa phases

Perhaps most strikingly, the C-14 dates collected from Dabʿa are in agreement with the ‘high’ chronology, but not accepted by the site director because of the conflict with the relative chronology based on historical anchor points (Kutschera *et al.* 2012; Bietak 2013; Bruins 2010). The C-14 dates of the site have been summarized most fully in a recent paper by Kutschera and colleagues (2012) after a lengthy time of being discussed but not published (Bruins 2010). Kutschera selected 47 short lived samples from the different phases at Tell el-Dabʿa, and used a Bayesian model on 40 dates showing the consistency of the general phasing itself – in terms of stratigraphic sequence – yet confirm an important age offset of ~120 years between the historical phasing and absolute dates (Kutschera *et al.* 2012, 414; 418: Fig. 7; **Fig. 4.5**). As visible in **Figs. 4.5** and **4.6**, this discrepancy in the absolute dates of phases at Dabʿa has significant consequences for the identification of historical events, such as the Hyksos rule, with the stratigraphic phases at the site. The problem lies with the way the relative chronology was established at Tell el-Dabʿa. A crucial critique of the Dabʿa chronology has recently been published by Felix Höflmayer (Höflmayer 2015).

Another issue with the chronological scheme lies with the short life of the phases at Dabʿa (30 years). As Bourriau (2000: 190) indicates, the basis the ‘30-year’ span is an archaeological construction using two set dates for the reign of Egyptian kings, as

the start of Phase H is dated to the reign of Amenemhat IV (1786-1777 BC) and the end of phase D/2 to the reign of Ahmose (1550-1225 BC). The resulting period is divided into nine phases with fixed timespans. Moreover, graves are said to be dated by their stratigraphic sequence of cutting into the deposits (Forstner-Müller 2008) yet few of these sections are published. It is more likely that the graves are dated on the basis of the artefacts they contain (seriation), and the vessels on the basis of this chronology. We thus run the danger of circular reasoning using these relative dates (they will keep confirming the relative chronology).

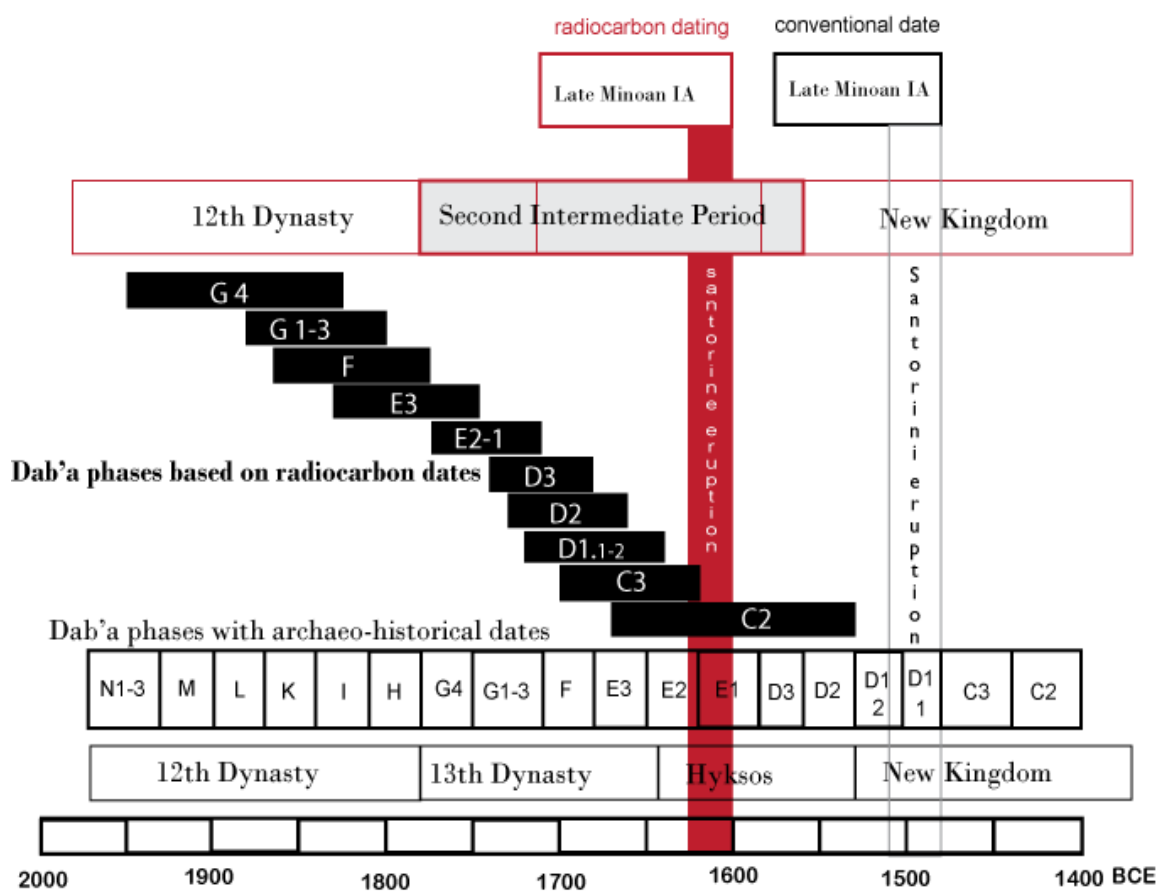


Fig. 4.5 (after Bruins 2010, 1490): The scheme shows the discrepancy between the conventional dating and the radiocarbon dates (in red and dark blocks) for the sites. Significantly, the Santorini eruption would fall within the 2nd millennium BC in the Second Intermediate Period, and not at the start of the New Kingdom.

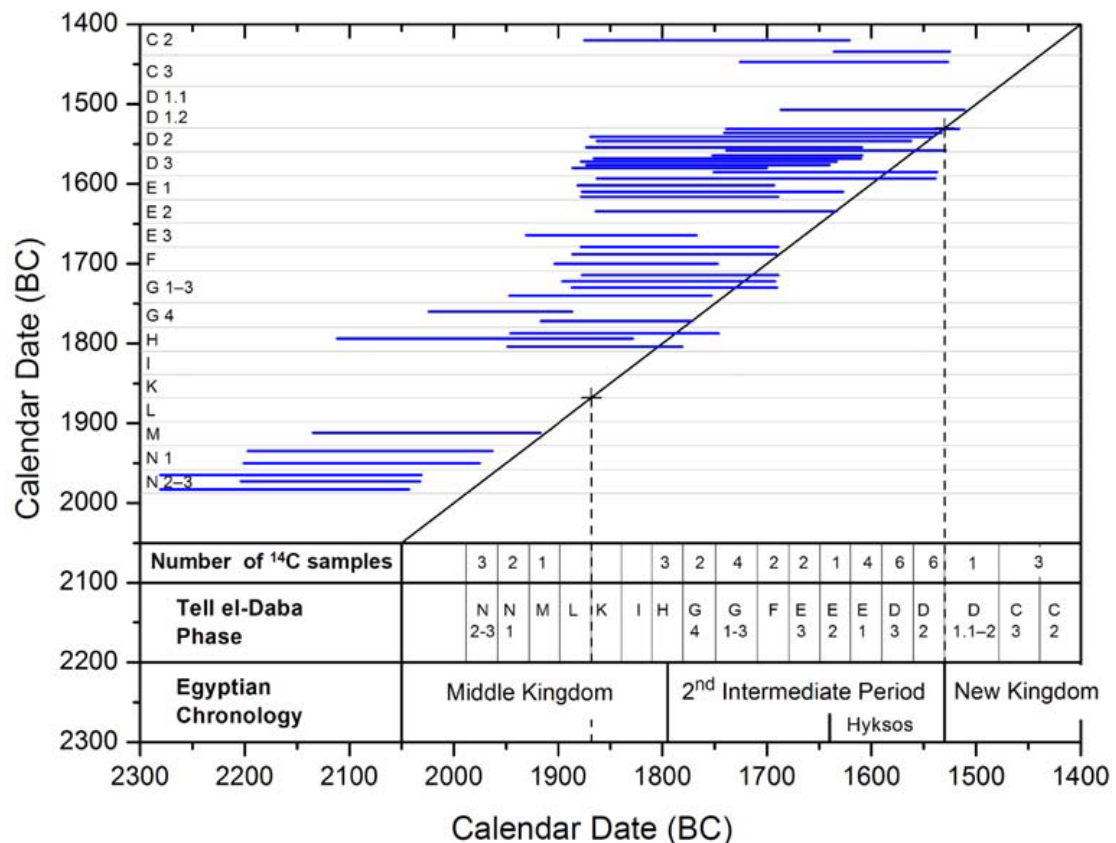


Fig. 4.6 (after Kutschera *et al.* 2012, 415) showing the discrepancy conventional dates and calibrated radiocarbon dates (2-sigma indicated in blue).

It is not stated that the whole stratigraphic sequence should be doubted, but it seems likely that vessels might be called ‘residual’ or belonging to a certain phase on the basis of the assumption that they are in the right phase. Without clear quantification of possible residual artefacts, it is impossible to evaluate this data since the graves are published by these phases and thus gain a scientific rigor in the literature. It is thus significant that Bietak recently admitted that the phases do not have to be of equal length (Bietak 2013, 81). This is relevant when we discuss the mode and tempo of the evolution of Tell el-Yahudiya juglets.

4.3.6: Overlap in rule of Second Intermediate Period dynasties

A second crucial point which plays an important role in the discrepancy in dates is the number of parallel dynasties ruling during the Second Intermediate Period, with the 14th and 15th (Hyksos) Dynasties in the Delta (capital Dab^sa/Avaris) and 16th and 17th Dynasties ruling from Thebes (Ryholt 1997). For example, recent debate has centred on the 15th Dynasty Hyksos ruler Khayan. Scarab seal impressions bearing his

cartouche have been found in association with a pit (L81) in association with a palace at Dab^a, dated to phase D/3 (transition E/1-D/3) and thus around 1590-1560 BC in the conventional chronology (Bietak *et al.* 2012; Aston *et al.* 2009; Sartori 2009, 285-288). However, seal impressions of Khayan have also been found in the same context as seals from a minor late 13th Dynasty ruler (Sobekhotep III) (though admittedly secondary; refuse pits) at Tell Edfu (Moeller *et al.* 2011; Höflmayer *forthcoming*). If this is taken to represent the contemporaneity of these rulers in the Delta and upper Egypt respectively, it would suggest the 15th Dynasty at least partly overlaps with the late 13th Dynasty, thus allowing phase D/3 at Dab^a (within the 15th Dynasty) to fall in sync with this rule around a century earlier (Höflmayer *forthcoming*). This would mean that many contexts yielding Tell el-Yahudiya ware in Egypt should actually be placed in the context of the late Middle Kingdom.

In the figures adopted from Bruins (**Fig 4.5**) and more recently by Kutschera *et al.* (**Fig. 4.6**), it can thus be seen that the phase G/4, conventionally dated to the 12th Dynasty and starting around 1770 BC in the conventional scheme (low chronology), actually starts nearer to 1950 cal BC (more in line with the onset of the Middle Bronze chronology of the Levant: Dever 1992 and see now Höflmayer 2015). It is around this phase and the subsequent G/1-3 that we find the first Tell el-Yahudiya juglets at Tell el-Dab^a (Aston and Bietak 2012, 57). The following phases show considerable overlap, henceforth, if we have a vessel with a relative stratigraphic position in phase E/3 according to the radiocarbon dates, it can be contemporary with phases G/4, G1-4, F, and E/2-1.

Where does that leave us in terms of explaining the evolution of Tell el-Yahudiya ware? It is not the goal here to get further submerged into the chronological debate of the 2nd Millennium BC in general as it remains highly contested, but for the purpose of this thesis, it is important to be able to have a grip on possible causes and effects, and selective pressure on different temporal scales. Hence, it is significant to know what role Tell el-Yahudiya ware plays in the early stages of development at one of the most dominant sites of use – Tell el-Dab^a – together with other typical Levantine material culture. Similarly, Tell el-Yahudiya ware goes out of use at Tell el-Dab^a around phase D/2 when the decoration is mostly executed as continuous horizontal or diagonal combing (Aston and Bietak 2012, 557). Traditionally, this phase has been seen as marking the end of the Hyksos rule in Egypt as well, soon after they were

expelled from Avaris by Ahmose, initiating the start of the 18th Dynasty (Ryholt 1997, 307-308).

However, if the radiocarbon dates are in fact correct, they have significant implications for the suggested end of the Hyksos rule after phase D/2, as the radiocarbon dates suggest that the following C/3 and C/2 phases, conventionally dated to the Early New Kingdom, are actually still within the Second Intermediate Period under Hyksos rule. This implies that the abandonment after phase D/2 in area A/II cannot be equated with the victory of Ahmose over Avaris and the expulsion of Hyksos (Bietak 1989b, 96-99). Only one of the consequences of this shift in dating, but very significant for the narrative in this thesis, would be that equating the end of Tell el-Yahudiya ware at the site (after phase D/2) with the end of the Hyksos rule is incorrect. Instead, the absolute chronology would suggest that the Tell el-Yahudiya ware became 'extinct' earlier, during the Hyksos rule but before or during the early parts of the 15th Dynasty rulers (see Chapter 7). However, the conventional start of the 18th Dynasty (under Ahmose) and Late Bronze Age around 1550 cal BC is well supported by recent C-14 studies, suggesting a start in the mid-16th century with an upper limit of 1573 (Bronk Ramsey 2010; Shortland and Bronk Ramsey 2013; Dee 2013).

Considering the prolonging strife between the Hyksos dynasty and the rival Dynasties to the south, it is quite likely that the inhabitants of Avaris, and the Hyksos rulers, had to work under economic and material constraints imposed by the accessibility of raw goods (and perhaps even artisans), at least from upper Egypt, as access to good stone material (with the quarries down south) for building might have been blocked by the rival dynasties in upper Egypt. This would make much sense as Apophis is the single longest ruler of the Hyksos Dynasty (around 40 years) yet his building activities are suggested to have mainly comprised the usurping of older monuments (Ryholt 1997, 143-148). This might be paralleled on a smaller stone-working artisan's scale in the large scale re-use of older stone vessels in the Second Intermediate period, which are often worn and show signs of heavy use (Bevan 2007, 102). Another tantalizing hint might be in the imitation of stone *kohl-pots* (including the drilling hole in original stone vessels) in locally made ceramics, which suggest that there was a cultural (ethnic?) demand for kohl-pots, yet an absence of useable

stone (or artisans) (Bietak 1991b: Fig.137.8, 191: Abb. 145.1-2: with the imitated drilling hole).

Concluding, conflicting chronologies result in a Second Intermediate Period of quite different lengths. This influences the discussion on the position of this vibrant hybrid community in the Delta and its access to materials and cultural practice, either ruled by Hyksos overlords or still part of an international trading community under Egyptian Middle Kingdom hegemony. It can be argued that the development of Tell el-Yahudiya juglets within Egypt, although initial demand was rooted in Middle Kingdom Eastern Mediterranean trade, was heavily influenced by developments at the site of Dab^ʿa, which yielded approximately half of the known assemblage. The political rule itself might just as much be a result of these processes, and no causal connection should necessarily be drawn between the 'Hyksos' rule and development in pottery (see for further critique below). Hence, it is of the utmost importance that the narrative framework is untangled from narratives on the historical chronology in the first place, as these are likely to shift in the near future. The development of Tell el-Yahudiya ware needs to be linked first to archaeological contexts and related to the selective pressure on the community in which Tell el-Yahudiya ware was used and produced, foremost at Tell el-Dab^ʿa. The evolutionary studies conducted below can help establishing this link. The chronology should primarily be based on the available C-14 dates, which actually put the Tell el-Dab^ʿa stratigraphic sequence in line with recent evidence from the rest of the Eastern Mediterranean (Höflmayer 2015). If we can relate the evolution of Tell el-Yahudiya juglets at Dab^ʿa to processes at the site influencing the wider region, Tell el-Yahudiya juglets can have a function (again) in providing relative dates in the Eastern Mediterranean, and in synchronizing assemblages, this time fundamentally based on absolute dates. We will come back to this issue in the final discussion (Chapter 7).

Part II: Phylogenetic analysis of Tell el-Yahudiya juglets

4.4: Methodology

The general methodology of the phylogenetic methods has been discussed in chapter 3. Here we will discuss the choice of taxa and characters for the Tell el-Yahudiya case-studies in more detail.

4.4.1: Choosing characters and taxa

The choice of characters for coding and taxa as levels of analysis forms an essential part of the actual evolutionary analysis of a certain artefact type, making use of cladistics or other methods of analysing developmental patterns. It is important to be explicit in what a character is and what it relates to, and what level of transmission a group of taxa represents.

In this thesis, a character is seen as a characteristic feature that relates to a direct or indirect action of a craftsperson. This action can be deliberate or non-deliberate and be based on transmission of knowledge either directly from person to person in the form of learning (verbal transmission and imitation actions), or from the observance of characters in artefacts that may or may not be directly related to a particular crafts-tradition a person is working in, in the latter case copied from outside traditions (§ 2.5.1, 3.2). In this regard, a distinction has can be made between vertical, oblique and horizontal transmission (Shennan 2002, 40; Mesoudi 2011, 57: Table 3.1) (§2.4.4; 3.2)

4.4.2: Dependency of characters

It is generally accepted that characters defined for a cladistics study should be independent, or at least assumed to be (O'Brien and Lyman 2003, 145; Nunn 2011, 25, 28). The independence of characters is important as they increase the likelihood that a suggested cladogram shows an approximate evolutionary pattern. If characters are largely dependent upon each other, this has implications for the principle of selection and the causes of change, where related characters might change due to a single selective factor. As has been suggested, assuming independence for characters in genetic studies is less problematic than cultural characters (Nunn 2011, 25). Moreover, independence might be assumed but in fact congruence of more characters,

showing identical development along a cladogram, might suggest they are linked (O'Brien and Lyman 2003, 145).

In our case, within ceramic fabrication, independence of characters has to be considered seriously, due to the fact that decisions early in the stage of production might influence later decisions. For instance, the decision to create a pointed base leads to the decision of having to add a knob or ring for stability. A decision to leave the vessel un-slipped can have consequences for the type of painted decoration which can be successfully applied at a later stage. In ethnographic literature on ceramic production, the independency of a potters' decision is still a matter of debate (see § 3.6.5).

It is important to distinguish independence in terms of hypothetically independent and practically independent. In practice, certain characters can be technically independent but socially strongly connected, the obverse, where characters are socially independent (or conceived as such) but technically independent are possible as well. Thus, a certain *chaîne opératoire* likely consists of a behavioural pattern that combines actions that can be socially and technically dependent or independent. Importantly, social independence, for instance due to social constrictions or perceived ways of doing things within a certain community of practice (§2.2.4), are just as relevant as technical independence of characters, yet understanding social dependence of behaviour seems hard to quantify. In order to understand the choice of characters and their dependence from a technical stance, a short experimental reconstruction of a number of juglets was done at Leiden with the aid of an experienced potter. Yet first we have to treat an important factor in the *chaîne opératoire* and the idea of dependent and independent choices: the use of the potters' wheel.

4.4.2: Tell el-Yahudiya juglets and the controversy surrounding the wheel

As noted in §2.3.2 there is discussion concerning the exact use of the wheel in the Bronze Age Levant. Nevertheless, certain characters in Tell el-Yahudiya juglets display tell-tail indirect signs of fabrication on the fast wheel. This is already attested by Aston and Bietak (2012a, 57), who note that the characteristics of the base in particular highlight the possibility that juglets were thrown on the wheel and finished upside down (**Fig. 4.6**). This fits with recent archaeological theories concerning the spread of the wheel from northern regions into the Levant (and Egypt), particularly its

use to throw small vessels (Roux and de Miroschedji 2009, 170; Roux 2015a). Interestingly, Arnold and Bourriau (1993: 61) suggest that a significant change occurs in the 13th Dynasty and is more marked from the 18th Dynasty onwards. It is exactly in the Second Intermediate Period between the 13th and 18th Dynasty that we find the Tell el-Yahudiya ceramic tradition in Egypt and this is in agreement with Aston and Bietak's statement (2012a: 58) that the fast wheel must have been introduced around this time. In this regard, it would be exactly at Tell el-Dab'a, with its increasing size and known as a hotbed for mixing cultural practices (including pottery making), that we would expect these developments in pottery technology to take place and wheel throwing to gain its crucial momentum.

To test the way the wheel might have influenced decision making of potters producing these juglets, the drawings, verbal descriptions, and photographs of published juglets from Tell el-Dab'a were studied for signs of the techniques used, and using these 'indirect' hints, experiments were conducted in Leiden by experienced potter Loe Jacobs, which led to a reconstruction of the likely *chaîne opératoire* (Fig. 4.7).

4.5: Experiments with the *chaîne opératoire* of Tell el-Yahudiya juglets

To get a better understanding of the technical choices a potter had in making Tell el-Yahudiya juglets and the way such choices were independent of – or were related to — previous actions, experiments with reproducing Tell el-Yahudiya juglets were conducted. These experiments, although not fully replicating ancient conditions, (e.g. use was made of a modern (electric) wheel, locally available clay, and a modern kiln), do give a good understanding of the likely way the juglets were produced after the adoption of the fast-wheel at Tell el-Dab'a. These experiments involved throwing the juglets off a hump of clay centrally positioned on the wheel ('off the hump'), with the marked feature that the vessel is turned around and put back on the wheel to finish the base, after an initial phase of drying (see Fig. 4.7 and Table 4.5). This particular *chaîne opératoire* (not including clay procurement and mixing at this point), leads to decisions along the production chain of the potter and can be related to characters we use in the cladistics analysis. During the experiment, the potter (Loe) threw

approximately eight juglets off one hump, after which the process could start with a new cycle.

In this way, the decision of the potter along the way, and the particular characters these yield within the *chaîne opératoire* could be metaphorically compared to genetic DNA chain (§2.3.7). Mutations in the *chaîne opératoire* cause morphological changes in the ceramics. These mutations can occur both intentionally and unintentionally, and rely on the actions a potter takes (room for *Lamarckian evolution*: Mesoudi 2011, 43). We have summarized the steps of producing a Tell el-Yahudiya juglet on the fast wheel in the following figure (Fig.4.6)

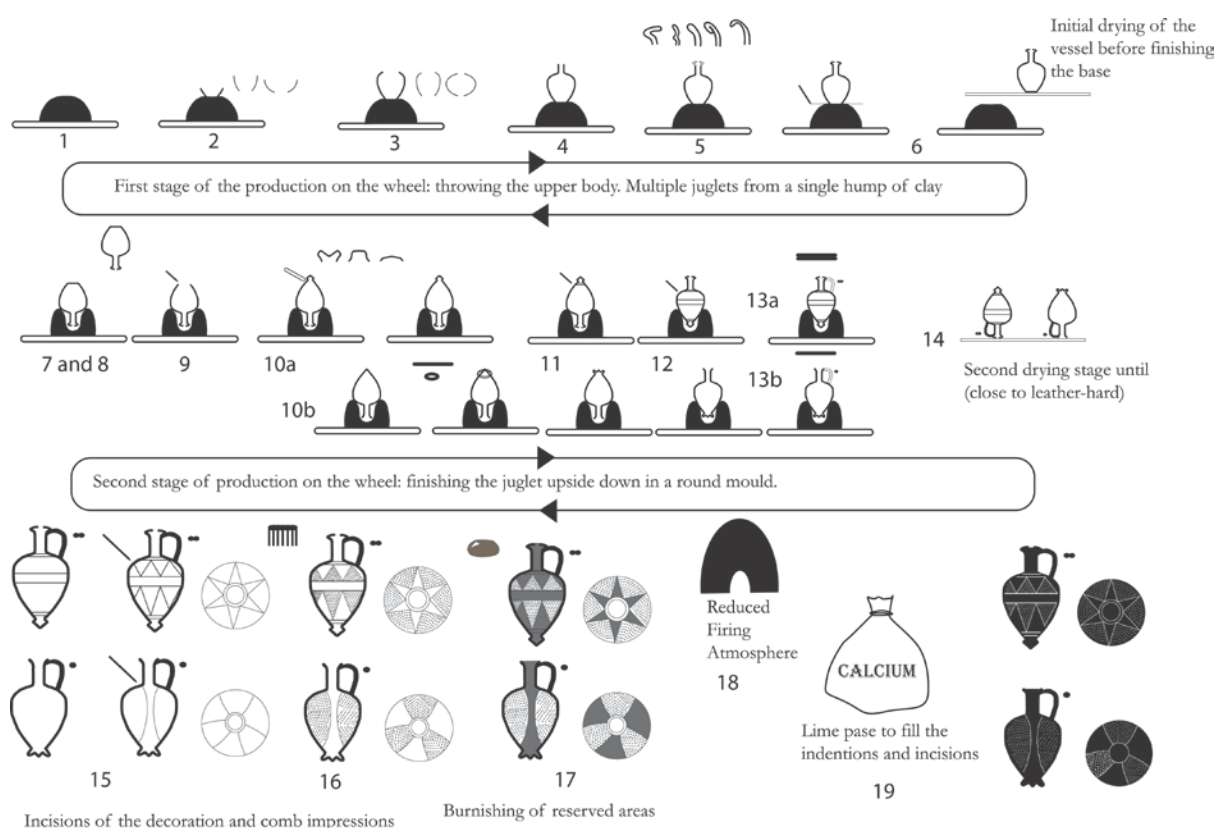


Fig. 4.7: Simplified scheme of the *chaîne opératoire* of Tell el-Yahudiya juglets thrown off the hump as likely produced at Tell el-Dab'a. Along the chain, a potter can decide on different characters.

Step in <i>Chaîne O.</i>	Category	Specific category	Description
1	Forming	Body	Placing a hump of clay centrally on the wheel.
2	Forming	Body	Opening up the hump with the thumb and delimitating the clay from the upper part of the hump with the sides of both hands: will form the walls of the juglet.

3	Forming	Body	The wall is drawn up. At this stage the potter can decide on the shape of the juglet by deciding the angle: for instance piriform or biconical. The wall is further drawn up by pressing the clay on the outside and inside, and max. diameter decided by the extent the potter pushes the clay wall outside and pulls up the wall
4	Forming	Body and neck	The forming of the shoulder, and working towards the neck. The neck is created by pushing the clay up in a cylindrical way with index finger and thumb of both hands .The length and diameter of the neck depends on the choice of the potter at this stage.
5	Forming	Rim	The rim will be formed. Here the potter has a number of choices, folding the rim, possible using a small tool to form inverted rims and folding rims outside.
6	Forming	Initial drying stage	The vessel is cut off the hump and set for an initial period to dry. Because the base is slightly thicker, it will dry slower keeping its plasticity for later forming.
7	Forming	ring	After the last juglet is formed the remaining clay can be formed into a ring to place the juglet upside down. Alternatively a ring stand can be put on the wheel.
8	Forming	Base/body	The juglets set aside to dry for an initial period can be put into the stand upside down. The potter will cut away an opening in the base, the clay being plastic.
9	Forming	Base/body	The potter will cut away an opening in the base, the clay being plastic, drawing up the base, defining the final shape in this way. When closing the base, the potter has various options concerning the type of base.
10a	Forming	Base	The potter can either shape the clay of the base with a tool, creating a button base.
10b	Forming	Base	Alternatively the potter can add a coil to create a ring base.
11	Decoration	Delimiting dec.	The potter has the choice to incise lines at the base that demarcate the area to be decorated at a later stage.
12	Decoration	Delimiting dec.	The juglet can be placed upright into the mould and lines can be incised at the neck and middle of the body.
13a	Forming	Handle	IN a stationary position, the handle can be made by multiple coils of clay (three coils, double coil, single coil).
13b	Forming	Handle	The coils are applied to the rim and shoulder of the

			vessel.
14	Drying	Second drying stage	The juglet will be set aside to dry again to a (near) leather hard stage before the stage of decoration. The juglet is probably set aside to dry upside (the top is already dryer).
15	Decoration	Decorative pattern	After drying the vessel is ready for decoration. With a sharp tool, the motifs for decoration can be incised, and relate to decisions by the potter for preferred designs.
16	Decoration	Combing	After demarcating the areas for decoration, a single point tool or comb is used to fill the demarcated areas with incised dots.
17	Decoration	Burnishing/polishing	When the clay of the juglet is leather hard, the non-incised area can be burnished with a pebble.
18	Firing	Firing	When the juglets are fully dried. They are ready to be fired. This occurs in a reduced atmosphere to create a dark surface. The polished surface will gain a dark (black) shine which can be held for a separate slip but the effect can be created by simply polishing the vessel in the previous stage.
19	Decoration	Lime filling	After cooling down, the incised lines and dots can be filled in with a lime solution.

Table 4.5: The basic steps in the *chaîne opératoire* illustrated in **Fig. 4.7**.

4.5.1 The influence of coiling.

Although this reconstruction is based on fast-wheel production, the choice of characters would be similar when the juglets were produced on a slow wheel with the aid of coiling (this may be assumed for the Middle Bronze I, see: Roux 2015a). However, as argued in chapter 2 (§2.3.2) the potential of speeding up the production would not be similar. In the evolution of juglets, it might be the case that more complicated design patterns, multiple coils for handles and elaborately folded rims occur in a tradition that spends more time on these characters, and is very much part of a ‘coiling’ dominated industry. This might also be reflected in the number of strands used in the handle (see below). Since these are made of clay coils, handles made of multiple strands added together might be related to a coil based industry, as the potter would readily have such coils at hand. This would be different were the potter to be throwing a juglet.

4.6: Differences in transmission: visibility of characters

As suggested in chapter 2 (§2.4.9) the visibility and technical malleability (ease of doing it) of ceramic characters influence the way they are transmitted (Gosselain 1998; Gosselain 2000; Gosselain 2008). This idea can be summarized in a table relating to Tell el-Yahudiya ware (**Table 4.6**, see §2.4)

Technique	Manu- facturing stage	Visibility	Technical malleability	Spatial constrictions	Vertical Transmission	Horizontal transmission
Applying decoration	Post- forming	High	High	Low	High	High
Firing	Post- forming	Medium	Medium	Low	Medium	High
Creating vessel shape	Forming	Low	Low	High	High	Low
Rim	Forming	High	Medium	Low	High	Medium
Handle	Forming	High	Medium	Low	High	Medium
Base	Forming	High	Medium	Low	High	Medium
Clay tempering	Pre- forming	Medium	Medium	Medium	High	Medium
Clay procurement	Pre- forming	Low	Low	High	High	Low

Table 4.6: The visibility and malleability of ceramic techniques and the way they might be for Tell el-Yahudiya vessels.

4.7: Levels of change: selective pressure and spatial-temporal levels

Overall, the evolution of Tell el-Yahudiya juglets would comprise roughly 450 years (from 2000 to 1550 BC). These 450 years should be taken as an approximate number, as Tell el-Yahudiya juglets form part of a broader tradition of juglet manufacture. As suggested, recently, C-14 dates could suggest the use of Tell el-Yahudiya juglets to end before 1550 BC, at least in the Nile Delta. However, the general consensus agrees on this time-stretch of 450 years, with the onset of the Late Bronze Age around 1550 BC, and it can be taken as a reference for now but should be extended by more absolute dating methods.

When addressing evolution and selective pressure, it is important to make a distinction in different levels of selective pressure. Within the framework of cultural change in the Levant, the last 20 years have seen an important focus on differences in patterns and temporal scales introduced through ideas borrowed from the *Annales school* (Braudel 1972; Fletcher 1992; Knapp 1992; 1993; Levy 1995). This school, based on the historical approach developed by Braudel and his successors, focuses on the different temporal and geographical scales that influence cultural and historical change. For our purpose, it is interesting that Fletcher called for an integrative theory that would target the reciprocity of cultural change and the hierarchy of time-scales (Fletcher 1992). According to Fletcher there still exists (at the time of writing) a disagreement about the explanatory status of ‘individual actions, cultural group process, behavioural parameters, and environmental factors as regulators of cultural life’ (Fletcher 1992, 45). What is important to stress is that this influence is not unilateral, but an individual can influence cultural group processes in the long run, and environmental factors play a key role in cultural change up to the level of the individual. Hence, the action of a ruler (say Khayan) can influence the development of trade with the wider Mediterranean, and environmental degradation can force cultural processes, such as choices made by potters regarding raw materials (see § 2.4.5). It is interesting that Fletcher called for a ‘selectionist’ framework to deal with the issue of the different rates of cultural replication and the hierarchy of explanations (Fletcher 1992, 45-46).

For our Tell el-Yahudiya study, we can focus on different temporal and geographical levels of change that address decisions and cultural transmission at different levels and so relate different scales of selective pressure. Our first case study focuses on communities of potters that transmit ceramic practices on a large geographical scale over a medium-long time frame (500 years). Selective pressure would relate to political changes, the opening up of trade routes, demographic pressure and changes cultural (and technological) practice (see §2.4.6; §3.3 on TRIMS). The same counts for our second case study, but this study focuses on communities of potters at a single site (Dab’a) that undergoes these same selective pressures but allows us to zoom in more detail. The third case study relates to the role of possible individuals, as it examines the hypothesis of a potter that learnt his/her craft in Cyprus and migrated to Tell el-Dab’a where s/he made juglets that might have

influenced the evolution of a certain type of globular juglet. The ‘long-term’ timeframe is not specifically explored in these case-studies, as it would involve the study of juglets and their role and change through time within the framework of millennia, and relate to selective pressure at the scale of environmental constraints and geographical possibilities and constraints, and relate to deeply entrenched belief systems and perceptions of the afterlife. These are not unique to the 500 year episode which includes the use of Tell el-Yahudiya juglets, but stretch for millennia and show that the Tell el-Yahudiya juglets are just an episode in this long-term sequence. However, the role of juglets and their contents in funerary rites (as related to *longue durée* ideas of the afterlife and the use of fragrant oils) will be taken up again in the discussion of this chapter (§4.13.1). The different temporal scales and levels of selective pressure can be summarized as follows (See **Table 4.7**).

Temporal scale	Long-term	Middle-term	Short-Term
<i>Annales school</i>	<i>Longue Durée</i>	<i>Conjunctures</i>	<i>Événements</i>
Years	Millennia	Decennia-centuries	Days to years
Transmission	Long term traditions/ deeply engrained cultural customs: <i>Importance of the afterlife, Perceptions of cleanliness. Clay sources</i>	Traditions: <i>Family/ workshop transmitting material cultural traditions, burial traditions, chaîne opératoire.</i>	Individual invention: <i>Copying, agency of individual and single artefacts</i>
Evolutionary mechanisms: selective pressure	- Environmental constraints/ geographical possibilities and constraints. - Deeply entrenched belief systems	- Political changes. opening up of trade routes. Demographic pressure -Changes in cultural practice.	- On individual, individual choices, constraints for households.
Dab’a Tell el-Yahudiya case study	Juglets as containers and grave gifts. Tell el- Yahudiya just an ‘episode’ in continuous process	Evolution of Tell el- Yahudiya juglets at Dab’a. Adoption of the fast wheel.	Cypriote migrant potters. Introduction of new techniques and inventions

Table 4.7: different levels of selection and how this reflects in the Tell el-Yahudiya case-studies.

4.8: Case study 1

General groups defined in the literature: the idea of evolution between communities of potters

As mentioned above, in the new publication by Aston and Bietak (2012), the Tell el-Yahudiya corpus is divided into branches (see **Fig. 4.4-5** above). What the authors have suggested here on the basis of their grouping of data, and patterns in distribution already studied by Kaplan and her predecessors, is basically a phylogenetic pattern where an initial ancestral group of vessels in the Tell el-Yahudiya tradition branches into two dominant clades of a Palestinian group and an Egyptian group. An intermediate phase is seen in ceramic traditions within the Northern Levant that preceded the developments in Egypt. This development is on such a scale that it does not represent the transmission of ceramic traits by individuals, but would rather entail ‘communities of practice’ or ‘communities of potters’ (Arnold 2008, 38-40; see § 2.2.4).

An ancestral group is hypothesized in group A (Primeval) which is mostly represented by the ‘Afula juglets (Aston and Bietak 2012, 58; Zevulun 1990). This primeval group would constitute a community of potters in the sense as explained above, and in our further analysis (case study 1 and 2) forms the outgroup *hypothesized* to be closest to the oldest common ancestor of the Tell el-Yahudiya ceramic tradition. From this ancestral group, Aston and Bietak suggest that a branching event (though not expressed in those terms) lies in the formation of two distinct groups (or clades in our terminology) with a ‘Palestinian’ group produced in the Southern Levant (branches B-D) and an ‘Egyptian group’ with production in Egypt (E-I) branching from the main ancestor (Group A). Moreover, group J, representing juglets with naturalistic designs, forms an intermediate group of ‘Levanto-Egyptian’ vessels that stands between these two main branches and were produced both in the Northern Levant and Nile Delta. A further branch N is seen as a separate tradition in being handmade. We will treat the ‘N’ branch in more detail later, as most vessels in this group could represent a Cypriote potter (tradition) migrating to Tell el-Dab’a in the Egyptian Delta (our third case study). The branching of these main groups can be seen in the tree-like reconstruction as published by Aston and Bietak (Aston and Bietak 2012, 52: Fig. 9, 53: Fig. 10; **Fig. 4.4-5**).

As an initial test of the appropriateness of an evolutionary framework, it might be good to find out if this perceived pattern is actually quantifiable with phylogenetic methods. Moreover, it will also test our ceramic approach and the characters we define in establishing these patterns. This preliminary, rather crude stage of analysis might give us information on multiple levels.

Now the division into branches and the following subdivision by numerals and letters has left us with a plethora of groups (see **Table 4.8**). In order to have a workable dataset to analyse with cladistics methods, a choice had to be made regarding the branches (our taxa comprise multiple branches) to be incorporated in the analysis. A principle selection was made to include closed forms with relatively constricted necks (traditionally called jugs and juglets). This is a more workable dataset because they share characters other than decoration alone. In this regard, branches representing animal figures were not incorporated (branches B5-6, L15) for this study because they seem to use different production techniques (including moulding) and share with the juglets only a similar decoration applied at the end. Open vessel shapes such as cups and bowls, though interesting in themselves because they share a decorative style and suggest that decoration itself can be transmitted fluently across shapes, are not included in this preliminary analysis (branches P (open forms), Q, ring-stands) (though their relevance will be discussed briefly in the discussion). Branch K could be dismissed since it was reserved for finds representing an expected late tradition in the geographical area of present-day Syria (like Petrie's blank numbers in seriation). Other groups are ill defined (basically outliers), such as group 'M: hybrid', which seems to define vessels not fitting in the other categories such as I and J, but these categories themselves can be seen as hybrid (Aston and Bietak 2012, 295: Branch M).

4.8.1: Taxa and Characters

To comprise the dataset, 20 taxa were chosen which can represent multiple defined branches. The taxa correspond to the larger communal groups of vessels (Aston and Bietak's genetic mainstreams). A summary of these groups can be given as follows (**Table 4.8**).

4.8.2: Characters

Relating to these 20 taxa, 45 characters could be defined using a binary opposition of presence (1) and absence (0). This way of coding the characters was chosen in order to allow a taxa to contain more than one character state of, for instance, vessel morphology (ovoid *and* piriform), handle shape (tripartite *and* double stranded) etc. This flexibility was needed as the branches (and our taxa) are comprised of a combination of techniques and choices being professed by the community of potters, representing multiple individuals working throughout multiple generations (decennia). In a way, such an approach represents a top-down approach which is bound to neglect important details. The characters list and coding with binary states can be seen in the appendix (**appendix case study 1**).

The characters are divided into seven main groups which consist of 1) *vessel shape*, 2) *rim shape*, 3) *type of handle*, 4) *type of base*, 5) *decorative bordering*, 6) *decorative scheme*, and 7) *decorative patterns*. Within these broad categories, the following characters are present as summarized below. Note that these character states are taken mostly from the descriptions, but only used if they are thought to reflect technical practices and choices by a potter. The general problem remains that the characters are ill defined in the literature (as they are transmitted verbally and in text without being properly defined). I will therefore use broad definitions for these characters, but it has to be noted that they are in need of higher definition and quantification. However, I do want to stress that our characters relate to technical choices, rather than the strictly formal characters that often drive traditional typologies. Mathematical definitions might be useful to show small variations within these different technical choices (for instance the angle of an everted rim), nevertheless, the choice, either intentional or almost automatically, was to create an everted rim by folding the end of the clay lip outside with index finger and thumb. Small variations are expected and actually crucial, as these are the variations that can mutate under selective pressure. However, since I work with discrete characters, they do not have to be part of the definition necessarily.

<i>Taxa (A&B group)</i>	<i>Key sites where example occur</i>	<i>Geographical area Likely production</i>	<i>Reference Aston and Bietak 2012</i>
A: Primeval	‘Afula	Southern Levant	59-65
B: Early Palestinian	Jericho, Gibeon, Malacha (central hills); Megiddo, el-Jisr.	Southern Levant	65-81
C: Middle Palestinian	Jericho, Gezer, Ginosar, Ashkelon	Southern Levant, Northern Levant	86-92
D1: Late Palestinian (ovoid)	Megiddo, Lachish, Jericho	Southern Levant	99
D2-4: Late Palestinian II-VI (piriform)	Jericho; sites Israel; Deir ‘Alla, Tell Hammam	Southern Levant	99-105
D5: Late Palestinian V (biconical)	Jericho;	Southern Levant	112-120
D6: Late Palestinian IV (Cylindrical 2)	Jericho; Megiddo; Tell el-Ajjul	Southern Levant	120-128
E2-3: Early Levantine II	Tell el-Dab‘a	Northern Levant	128
F: Early Levantine III-VII	Tell el-Dab‘a; Ebla; Fadous	Northern Levant	128-137
G: Carinated	Ugarit (Ras Shamra)	Northern Levant	137
H: Early Levantine VIII	Tell el-Dab‘a; Tell Burga; <i>Lisht ware</i>	Northern Levant	137-142
I: Levanto- Egyptian	Tell el-Dab‘a, Tell Arqa, ‘Afula, Megiddo, Fayoum, Memphis, etc.	Northern Levant/Egypt	142-193
J: Levanto- Egyptian (naturalistic designs)	Tell el-Dab‘a; Toumba tou Skourou; Thebes, Bernasht; Byblos; Ashkelon,	Northern Levant/Egypt ‘Lisht ware’	193-200

L1: Egyptian I (Piriform 2)	Tell el-Dab ^a	Egypt (Delta)	206-211
L2-8: Egyptian II- VIII (biconical)	Tell el-Dab ^a ; Ashkelon	Egypt (Delta)	211-254
L9: Egyptian IX (globular)	Tell el-Dab ^a ; Tell el-Yahudiya	Egypt (Delta)	254-257
L10: Egyptian X (Quadrilobal)	Tell el-Dab ^a ; Tell el-Yahudiya	Egypt (Delta)	257-265
L11-12: Egyptian XI-XII (Cylindrical)	Tell el-Dab ^a	Egypt (Delta)	265
L13: Egyptian XIII (grooved)	Tell el-Dab ^a ; Hebwa; Enkomi (Cyprus)	Egypt (Delta)	265
N: Handmade globular	Tell el-Dab ^a	Egypt (Delta)	302-326

Table 4.8.: General groups devised by Aston and Bietak 2012 used as Taxa. Information on key sites and likely area of production (as far as can be deduced from recent petrographic and NAA analysis).

In terms of vessel shape, I use the broad classes first introduced by Kaplan (1980) and taken over by Aston and Bietak (2012). Although there is a lack of mathematical definition in these classes, they do seem to show consistency.

These classes are very basic and form the characters 1) Ovoid; 2) Piriform, 3) Biconical; 4) Globular; and 5) Cylindrical. In terms of definition, Ovoid is defined as a shape where the widest part is halfway the vessel body, and the angles of both the lower and upper part are equal or almost equal with similar gentle curves. Piriform is defined by a widest width of the vessel (pear-shaped) that lies within the upper part of the body, and a difference in the angle between the upper part of the vessel; as it is more curved than the lower part. Biconical is defined by a widest point approximating the middle of the vessel, where both upper and lower angles of the wall are rather similar and curved. Globular is defined as a vessel body where the widest point is in the middle of the vessel and the overall curvature of the upper part and lower part is similar and forms a globular shape (circular). Cylindrical is defined by a shape that has a widest that is varying, but where the sharpest curves are at the extremities of the upper and lower part of the body, and the vessel wall is relatively straight between

these curves. These definitions have been very much intrinsically present in archaeological literature. The shapes are almost instinctively recognized. However, it is important to note that the distinctions are harder to define mathematically, where, as Kaplan already suggested, the proportions form continuous data. This can be clearly visualised in a graph setting out the length and width of biconical and piriform vessels at Tell el-Dab^sa (see case study 2), and will play a role in our second case study as well. However, considering the consistency over a wide area these vessel forms can be taken as real recognized classes; thus both technical and *emic* (see § 2.2.10), and form distinct choices in the way potters formed the vessels. I will suggest later that these classes evolve through technical standardization of variations, and can spread by *emic* copying of a model. They are thus taken as discrete characters at this point. A full list of characters will be given in the appendix.

The size of the juglets plays no role in the character formation at this moment. This is not to suggest that size plays no role in the actual evolution of these juglets and does not show developments, yet the sizes for the various groups are not well defined, and only sporadically mentioned in the text (Aston 2012; Kaplan 1980). Moreover, vessels of different sizes can belong to the same group thus making the definition of discrete characters on size challenging. Other characteristics, such as surface colour, cannot be applied as they are not consistently mentioned for these broad classes and moreover, may vary considerably within a group. Nevertheless, a general chronological development towards smaller size of the vessels and a darker reduced surface has been noted (Kaplan 1980, 27)

4.8.3: Cladistic analysis

On the basis of these 20 taxa and the 45 binary defined characters, we conducted a cladistics analysis in PAUP, making use of a random heuristic search (due to the computational size of the dataset) (Swofford 2002: see §3.9.1 for further references).

The result of our random heuristic search is a single tree with a length of 132 (1729542 rearrangements tried (see **Fig. 4.8**). The Consistency Index is 0.3409, and the Retention Index is 0.5272. Both the CI and RI are relatively low but not unusual for cultural data (Collard *et al.* 2006b, 177; Nunn 2011). The RI of 0.5272 shows a relatively large proportion of homoplasy in the data, as a RI of 1 shows maximum homology (no conflicting character changes) (§3.9.6). Yet despite the significant

homoplasy, the pattern can still be explained by branching as well and there is no reason to suggest that blending was dominant overall (Collard *et al* 2006, 179).

A bootstrap analysis (10.000 repetitions) was performed to test the robustness of the clades (§3.9.7), and yielded a support of 58 % for clade I-J. The other branches were not supported by bootstrapping in over 50% of the random replications performed by the bootstrap analysis. A support of 70% has been suggested as a strong indication of the fact that the phylogenetic reconstruction is accurate (Tehrani and Collard 2009b, 293). However, such a result would likely demand too much of a dataset including this many taxa (and possible conflicting data) (see §3.9.7). This shows that in general, the branching pattern is not overly well supported, and the dataset should be analysed using network approaches to illustrate such reticulate data (see below). Moreover, a manual Bremer test was performed (by increasing the length of the trees and constructing a strict-consensus tree until the tree was completely unresolved) to see how many extra steps it would take to have an unresolved tree. The Bremer test also signified a support of 1 (length of 133, 82 trees retained) steps for the clade of taxa C, D1, D2-4, D5, D6, L1, L2-8, L9, L10, L11-12 and L13 (Middle to Late Egyptian *and* Palestinian groups) and a support of 1 step for the clade with taxa's I and J (Levanto-Egyptian groups), with the consensus tree being fully unresolved at a length of 134.

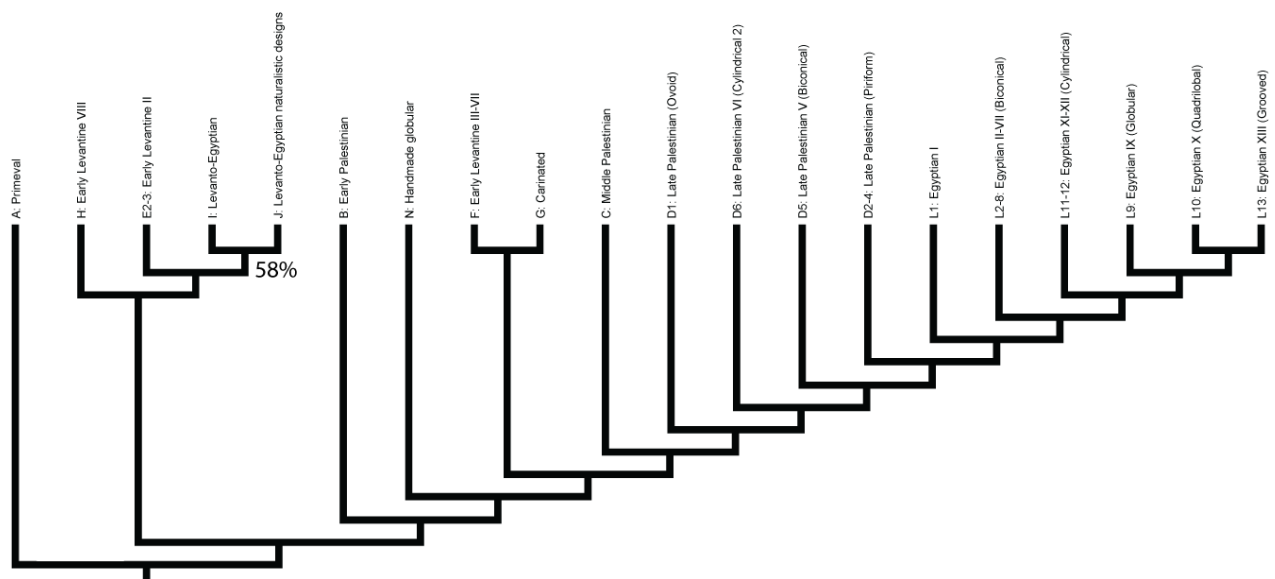


Fig. 4.8: Cladistics analysis of 20 taxa representing 'branches' and testing the perceived evolutionary pattern. Bootstrap result in % (Maddison and Maddison 2011).

4.8.4: Discussion of the results

With the above results, a single most parsimonious tree showing relatively low RI and bootstrap support, what can we say about the hypothesis of an ancestral group ‘A’ and the suggested branching pattern of a dominant Palestinian and Egyptian clade? In general, the tree suggests a large amount of homoplasy (character traits which are present in more than one taxa but do not share an immediate common ancestor: §3.6) (with a RI approaching 0.5, approximately half of the character changes are explained as such). Moreover, the clades of the single most parsimonious tree are not very robust, which suggests the evolutionary pattern is not very strongly supported. However, the tree does show some promising results, where the taxa do seem to branch in a pattern that is consistent with the established relative chronology. It suggests that the groups as established in previous research; and the temporal timescale of early, middle and late groups by Aston and Bietak (2012), shows a certain consistency.

This can be seen in the taxa branching off earlier in the tree are consistent with the groups that are associated with ceramic traditions in the Northern Levant (Taxa H, I-J, E2-3, see **Table 4.8**) and the Early and transitional groups in the Northern Levant, Southern Levant, and Egypt (Taxa, B-F and G, see **Table 4.8**). The early branching of the handmade group N suggests it is related to an early stage in the evolution of the Tell el-Yahudiya ware, though this particular early branching’s not consistent with the fact that the tradition is clearly set within Egypt (Tell el-Dab’a). It is likely that the handmade globular group N possesses a number of unique character traits that make it more parsimonious to branch off at this early stage in the tree. We will return to this handmade tradition in case study 3.

These early branches are not strongly supported by bootstrapping. The cladistic analysis does show a stronger support for the grouping in one clade of Taxa I and J which would be expected as they both belong to an already perceived distinctive group of Levanto-Egyptian vessels, where the distinction between I and J lies foremost in the presence of a type of decoration (geometric motifs in taxa I and naturalistic in J). I would suggest that this distinction is thus typologically artificial, and might not signify a large distinction in fabrication. This is very much in line with its perceived position as a ‘transitional’ Levanto-Egyptian style. In this regard, I and J might be considered to be a fairly consistent single tradition with a heterogeneous

scheme of decorative motifs. In the end, a choice could be made by the potter between decorating the vessels with naturalistic motifs, or with geometric motifs, either dividing the vessel into several panels or leaving the surface free of these lines to decorate in a free manner. These taxa are branching off relatively early, consistent with their perceived earlier date. Nevertheless, the cladogram does not support the position of these two Levanto-Egyptian clades as the direct ancestral group to the Egyptian group, where it would form an evolutionary stage between the (northern) Levantine vessels and the later Egyptian tradition. This is not to say that this hypothesis can be refuted on the basis of the cladogram, but it does show that such a crucial transitory position for these juglets is hard to quantify and probably needs to incorporate more detail on the characters on the basis of more careful study of their *chaîne opératoire*.

Another significant outcome is that the tree does not support the dominant branching pattern and splitting of the Egyptian and Palestinian groups. In our cladogram, the Egyptian group actually forms part of a larger clade incorporating the Palestinian groups. However, the Egyptian group does form a separate clade that branches off with a nearest common ancestor (node) which connects it with the taxa D 2-4, the Late Palestinian piriform vessels. However, the bifurcation from Taxa I-J (Levanto-Egyptian) group is not present. We will explore the possible reasons for this in some more detail.

First of all, there might be a problem with our definition of the taxa and characters. The definition of taxa is based on Aston and Bietak's (2012) work and would benefit more thorough testing of consistency, yet the groups seem to represent different ceramic traditions in a fairly consistent manner. The definitions of characters used in this analysis are crude by definition. This reflects back on the consistency in the descriptive literature. Characteristics such as 'plump piriform' are hard to quantify, and attributes such as the colour seem to vary to a considerable extent withholding their use as consistent characters, since they relate to more general firing conditions (degree of oxidization). The terminology in the literature is ill defined itself, yet based on experimental reproduction I suggest that the characters chosen do actually represent different technical choices and are thus relevant.

The two main conclusions of this cladistic test of the broad groups would be that if we take the groups of juglets as defined recently (Aston and Bietak 2012; **Fig. 4.5**) the tree shows considerable homoplasy and that the dominant split in between the Palestinian clade and Egyptian clade is not supported. This suggests that the scheme as defined by Aston and Bietak actually ‘glances’ over different ways of transmission of ceramic traits, likely incorporating considerable homoplasy. What it shows is that the Egyptian tradition with its middle and late Egyptian taxa seems to be a relatively more recent clade within the larger Palestinian clade. With the CI and RI scores suggesting considerably homoplasy, we might further explore what might cause this. As referred to earlier, homoplasy can be caused by various processes. What can be suggested is that the grouping of the Egyptian and Palestinian tradition in a single clade, with the splitting of taxa following the relative timing in a fairly consistent way, points to a consistent presence of parallel development. It might be suggested that the similarity in characters within the Egyptian and Palestinian groups is explained because of the similarity in evolutionary processes and selective pressure operating on both groups. This would mean that the selective pressure on changes in the ceramic characters might be similar in two geographical areas and lead to similar outcomes (parallel development in Palestine and Egypt). Moreover, we know that there are juglets belonging to the Egyptian tradition that are found in southern Palestine, and a small number of Palestine vessels that occur in the Delta. It is thus likely that the evolution of the juglets within these two main traditions show both reticulation (hybridization) and parallel developments causing considerable homology. Shapes (such as biconical juglets) were copied from late Middle Bronze Palestinian traditions, whereas design patterns arising within the developmental sequence within the Delta were easily copied by southern Levantine potters (see Chapter 7: discussion).

To test if the reconstructed phylogeny would alter much or show a different picture, and for instance would show the taxa of I and J (Levanto-Egyptian) as direct ancestors of one of these groups, we can enforce the difference of the Palestinian and Egyptian group, by conducting a cladistics analysis consecutively excluding one of these groups.

4.8.5: Excluding the Egyptian group

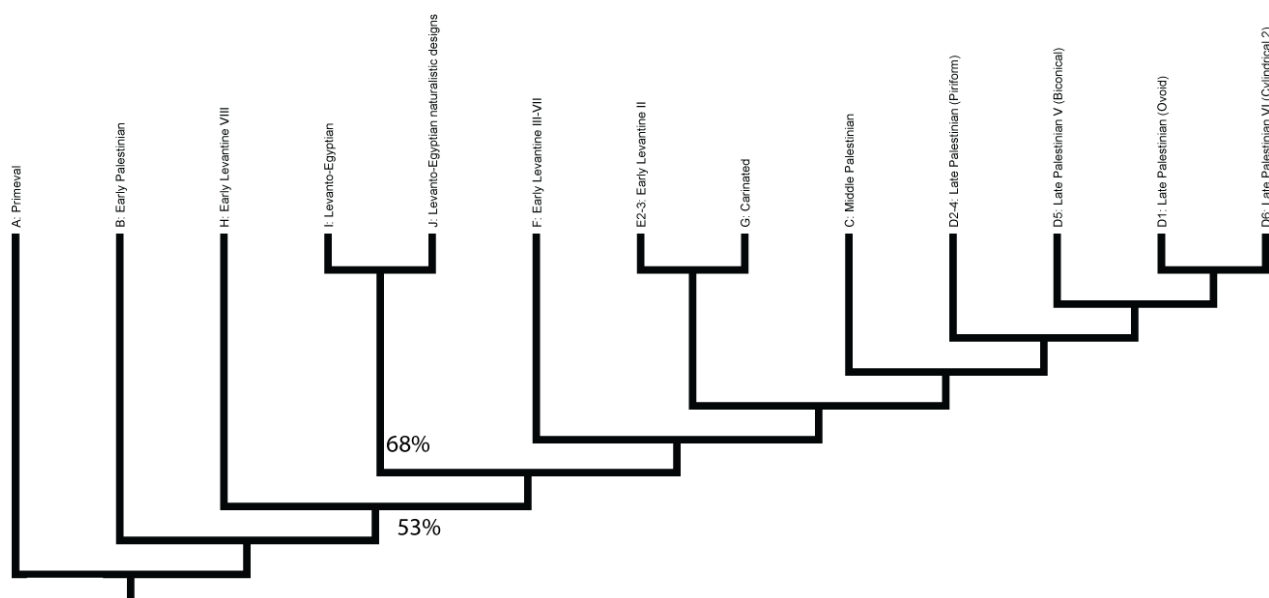


Fig. 4.9: Cladistic analysis excluding the taxa representing the Egyptian group. Bootstrap results indicated in % (Maddison and Maddison 2011).

If we exclude the taxa belonging to the Egyptian group (L1-13 and N) we end up with a matrix of 13 taxa and the same 45 characters. When we conduct a branch-and-bound search with these taxa, using the same outgroup, it yields a single most parsimonious tree with a length of 89 (30 parsimonious informative characters). The CI is 0.4328 (but dependent on the number of taxa and thus should not be compared between data) yet the RI is 0.5050. The RI is relatively low and shows considerable homoplasy. Bootstrapping (10,000 repetitions) supports the clade including C to –J excluding A and B and H) with 53% and the clade with Taxa I and J with 68%.

Dataset	RI
Whole dataset	0.5272
Excluding Egyptian group	0.5050
Excluding Palestinian group	0.5299

Table 4.9: Selected dataset and Retention Index

The branching pattern does not seem to yield substantial differences to the tree including the Egyptian group. Yet significantly, after an initial branching of the early

Palestinian group (B), there follows a pattern of branching that seems to be relevant to the northern Levantine traditions with the Early Levantine (H) and Levanto-Egyptian taxa (I and J) splitting off subsequently, the Early Levantine (F) taxa branching next, and the Early Levantine E2-3 and carinated (G) following. Subsequently, the branching pattern of the Palestinian group follows the division of middle to late Palestinian groups as envisioned in the chronological scheme developed by previous authors. This pattern would suggest that after an initial branching off from the early Palestinian tradition, the branching pattern is dominated by the evolutionary developments in the Northern Levantine ceramic traditions, positioning the following Palestinian traditions at the end of the tree. It might very well be that this reflects an early split between the Northern Levantine tradition and the Palestinian tradition. Geographically and historically, this would fit, as the outgroup with the 'Afula tradition lies between these two geographical regions, and the Egyptian contact with the Northern Levant is seen as more powerful in the initial phase (Especially the MBI: Cohen 2014) whereas the contact with the Southern Levant increases with the onset of the Hyksos rule (MBIII) (Bietak 2010a; Ben-Tor 2007; Cohen 2002). The early branching of the Levantine and Levanto-Egyptian taxa would corroborate such a framework. Yet due to the low consistency scores of the tree, we cannot draw too many conclusions from these results, although they offer tantalizing hints.

4.8.6: Excluding the Palestinian group

The same procedure can be followed as illustrated above by excluding the taxa belonging to the Palestinian group (excluding taxa B, C and D1-6), where we end up with 14 taxa and the same 45 (34 characters parsimony informative) characters. Using the taxa A: primeval ('Afula group) as an outgroup again, a branch-and-bound search (see §3.9.1 for further details) yields a single most parsimonious tree with a length of 98. The tree has a CI of 0.4388 and a RI of 0.5299. These are still low but the RI is slightly higher than the previous results, suggesting only slightly less conflicting data. Bootstrapping (10,000 repetitions) shows that there is a relative stronger support for the clade of I and J (56%) and for the clade representing the Egyptian ceramic tradition (L1, L2-8, L9, L10, L11-12, L13) of 69%.

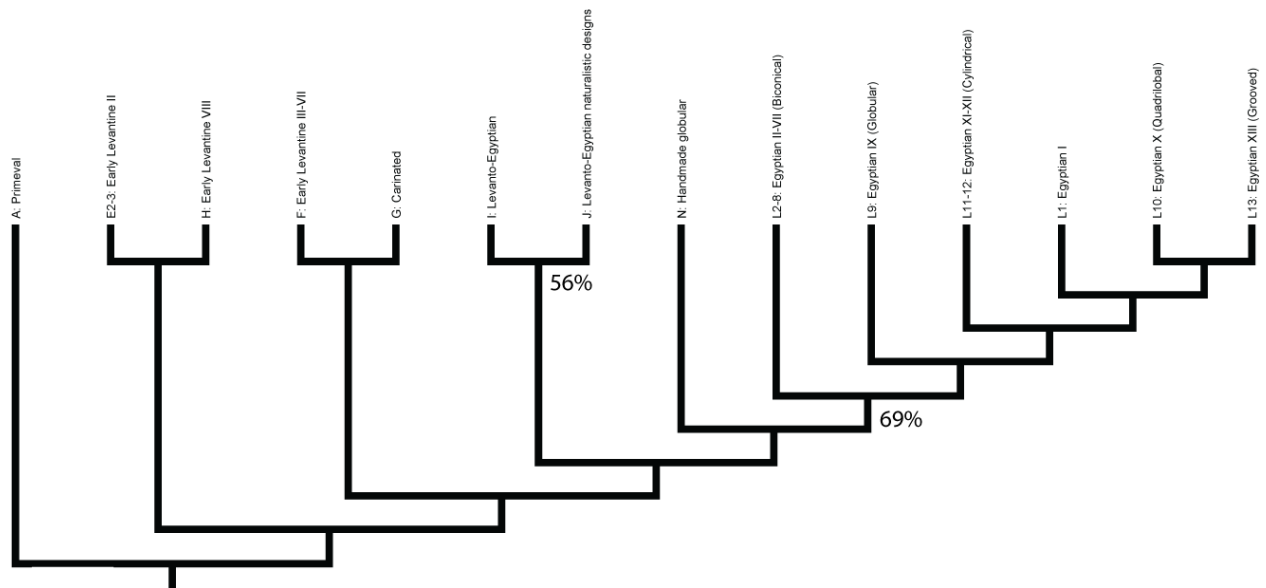


Fig. 4.10: cladistics analysis excluding the taxa representing the ‘Palestinian group’. Bootstrap results in % (Maddison and Maddison 2011).

This time, excluding the Palestinian tradition from the cladistics analysis, the tree yields a branching pattern that shows some interesting changes. The tree shows an early branching of the Early Levantine taxa again (E2-3; H; F and G). After these branches, the following branch is the Levanto-Egyptian tradition (I-J) forming a clade. With the handmade globular tradition (N, see case study 3) branching next, the Levanto-Egyptian taxa form a clade with the Egyptian tradition suggesting most recent common ancestry (this will be explored below: §4.9). This branching pattern supports the identification of this Levanto-Egyptian tradition as the ceramic assemblage that shows an evolutionary link between the ceramic traditions in the Levant and those taking hold in Egypt (foremost at Dab’a, as we will argue later: §4.9). Moreover, bootstrapping supports the clade with the Egyptian taxa with 69% (which is relatively high), although the internal branching is inconsistent with the stratigraphic data (see Aston and Bietak 2012a, 554, Fig. 252; 555, Fig. 253). For instance, the piriform ‘L1: Egyptian 1’ taxa would be closely connected to ‘I: Levanto-Egyptian’ both with predominant piriform juglets, however, the L1:Egyptian taxa shows that the cladistics analysis places its branching later, which might be due to the characters that are relatively late developments. Considering the overall results of the clade including the Egyptian groups it seems that we might rightfully call this an Egyptian tradition as the branching of this general clade seems to be relatively stronger supported by bootstrapping.

Thus, cladistics analysis excluding the Palestinian taxa shows that the Egyptian tradition can be seen as a separate clade indeed, and the analysis supports the distinctive nature of the early Levantine vessels as represented by the Levantine taxa. Recent petrographic and NAA conducted by Anat Cohen-Weinberger would support this idea as it suggests these juglets to be made at a number of different locations in the Southern Levant (Cohen-Weinberger 2008; Cohen-Weinberger 2011).

The cladistics analysis excluding the Palestinian taxa shows very interesting results, as it seems to show that the Levanto-Egyptian group I-J can indeed be seen relating most closely to the direct ancestor of the Egyptian taxa (with the handmade globular group N forming a relative early separate branch, fitting the chronology quite well indeed). Moreover, it shows that the clade incorporating the Egyptian taxa shows a stronger support (69% in bootstrapping) though the branching events within this Egyptian group are not as strongly supported. A number of juglets from this dataset were further studied creating a separate dataset, including information on the provenance, when known (§4.9).

4.8.7: Reticulate data: Splitstree analysis.

In order to further examine the probability of homoplasy and considerable horizontal transmission, the dataset was analysed using phylogenetic network analysis (see §3.10) for methodology). The result (Fig. 4.11) shows considerable reticulation of the groups. However, when the network is rooted (using outgroup A), a general branching pattern can still be recognized where the early taxa (A, B, H) are closer to the root, with transitional taxa I and E branching in the middle, and the Egyptian tradition (Taxa L) which form a netted cluster at the top. In short, the phylogenetic network illustrates the reticulate pattern, but when rooted emphasized the general pattern generated with the cladistic analysis. Two statistical values illustrate the relative degree of reticulation, the D-score and Q-residual (see §3.10.1 for details). Both the D-score of 0.3772 and Q-Residual score of 0.05915 indicate that there is a relatively high reticulated pattern in the data (Gray *et al.* 2010).

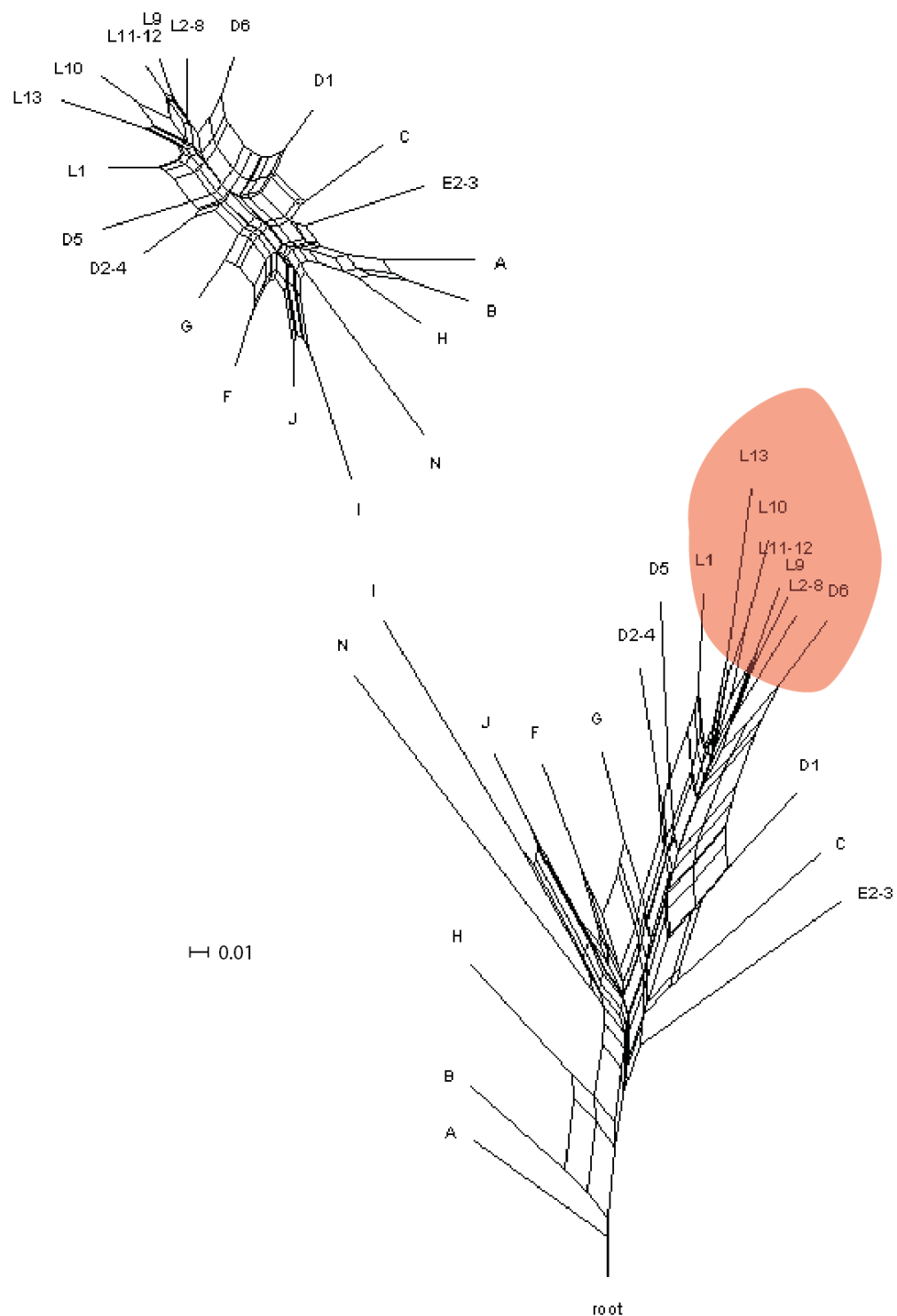


Fig. 4.11: NeighborNet plots of the data: To the left the unrooted data, showing a very netted; reticulate pattern in accord with the cladistic results. To the right a rooted network which shows a pattern with the early groups close to the root and Egyptian groups clustered at the upper extremity (indicated in red).

Retention Index	0.5272
D-score	0.3773
Q-Residual	0.05915

Table 4.10: The RI compared to the D-score and Q-residual score generated in SplitsTree (Huson and Bryant 2006).

4.8.8: Discussion of the results

The general pattern of the tree using 20 taxa and 45 characters yields a relatively low score of the CI and RI index suggesting considerable homoplasy in the form of reticulation (hybridization) and parallel development within this group of vessels. The reticulate pattern is supported by a phylogenetic network analysis. Character reversal (archaisms) might play a role as well. It has been noted that the earlier groups (early Levantine and Palestinian) are formed by vessels that are relatively rare and individual, in other words, which are probably not part of a mass produced industry (Aston and Bietak 2012a, 58-59). The taxa included vessels from a large geographical area, and what connects them is the overall similarity in decoration. Moreover, many of them possess characters that find a place in other parts of the local ceramic industry, such as the triple handles and the ‘candlestick rim’ which is seen as typical of the latest MBI phase (Aston and Bietak 2012a, 59; Cohen 2002, 55). This parallel in characters between Tell el-Yahudiya ware and similar juglets and other vessel classes decorated in a different manner continues, but gets a different significance once the replication rate (as of a species) or the production of vessels increase and form a consistent tradition of pottery making.

What might then be suggested is that up until the point of the later Palestinian and especially later Egyptian traditions, the evolution of Tell el-Yahudiya ware is marked by considerable horizontal transmission and the blending of ceramic traditions (in accordance with the wide distribution of its distinctive decoration). This early phase sees a heterogeneous collection of vessels with unique features that are made in different local traditions. The initial stage is thus marked by a clear role for ethnogenesis, i.e. patterns of blending (not to be mistaken with ethnic genesis of the ‘Hyksos’) and hybridization (Nunn 2011, 234-235). Ethnogenesis would be seen as the ‘group-level horizontal transmission’ (Nunn 2011, 235). It seems that especially in

the earlier phases of the Tell el-Yahudiya juglet production this transmission plays a key role. These processes find their resonance in the difficulty of achieving a clear cladogram with high level of homology. I define hybridization in this thesis in cultural evolutionary terms as the creation of new practices of mixed ancestry by groups of individuals from different cultural backgrounds who exchange cultural practices either directly or indirectly.¹²

What these preliminary conclusions might signify in archaeological terms of typology and practice would not necessarily come as a surprise to most scholars but might be interesting to stress from this evolutionary point of view. Namely that in the earlier stages, represented by the Early Levantine groups (but exported into Egypt (E2-3, F, G and H) there is not a consistent tradition of ceramic production resulting in a single ‘Tell el-Yahudiya ware’. With the eye of the modern archaeologist on the similarity in decoration, different ceramic traditions are corralled to form a single group – “Tell el-Yahudiya ware” – whilst at this point, what unites them is a common way of decorating. This might well relate to the fact that decoration is a highly visible characteristic, and is most easily copied via horizontal transmission (§2.4.9). Importantly, the separate traditions might have their own cultural drivers for these developments. Moreover, it turns out that in order to create the ‘evolutionary’ tree as published by Aston and Bietak (2012: see **Fig. 4.3-4**), implicit assumptions are made as to the significance of certain characters of the vessels (*character weighing*), yet these are not clearly stated but seem to rely on archaeological ‘gut feeling’. This process of ceramic qualification, where typology is transmitted verbally and categories are intrinsically internalised (a form of scholasticism) is not new, and is a recurring issue with attempts at quantification.

A second stage might be represented by the Levanto-Egyptian tradition (I-J) which seems to form a fairly consistent group of vessels with a heterogeneous tradition of decoration, but beginning to form a consistent tradition of vessel manufacture that is attested both in the Northern Levant and in Egypt. The third stage of the tree, namely the large clade with the Middle and Late Palestinian tradition, and the Egyptian tradition of Tell el-Yahudiya ware, might suggest two types of homoplasy (§3.6). These are in the form of: a) parallel development, though not

¹² Adapted from a definition on hybrid zones by Harrison (1993) I go into this theme in more detail in a forthcoming article: De Vreeze 2016a

necessarily at the same pace, and b) extensive copying of traits by both larger traditions. This is supported by the fact that the clades forming the Palestinian and Egyptian group still form a consistent clade when one of them is excluded from the analysis. These clades roughly correspond with the Middle Bronze III and the Second Intermediate Period in Egypt, when 15th Dynasty Hyksos ruled over considerable areas of Egypt from their capital of Avaris (Tell el-Dab'a) in the Delta, and significant contact between the Southern Levant and Egypt is attested archaeologically (Bietak 2010a, Ben-Tor 2007). The clade does show a branching pattern where the Egyptian taxa form a separate branch in itself, and even the pattern of branching within this group might be called consistent with the data (see **Fig. 4.9** and **Fig. 4.11**). Yet in reality, as established by the different geographical locations of these two traditions (shown already by Kaplan and elaborated by Aston and Bietak 2012), these two traditions seem to have developed fairly in tandem. It thus would suggest that parallel development might be responsible for similarity in characters. However, key types of shapes, such as a cylindrical shaped vessel, or type of decoration could have been transmitted horizontally as potters in both the southern Levant and Egyptian Delta emulate new popular styles. Such horizontal transmission is expected to occur as the areas were closely linked socially and economically. This is in line with the distribution of other material culture, such as metal weapons, stone vessels and scarabs (Philip 2006; Sparks 2007; Ben-Tor 2007). Again, at this large scale of analysis, a phylogenetic pattern of descent with modification of a ceramic tradition from a common ancestor is obscured partly because of other mechanisms of transmission.

In the end, what preliminary conclusion can we draw from this initial stage of analysis? The branching pattern as reconstructed through archaeological inquiry and most recently summarized by Aston and Bietak (2012) remains hypothetical and hard to quantify if we use these broad group definitions. This might be partly due to the scale of analysis and the lack of detail in character definition. Nevertheless, even though the cladistics analysis does not yield a clear-cut picture of 'descent with modification' because of considerable homoplasy which could relate to processes of borrowing and blending, this should not be seen as a disappointing result. Rather, this might partly be expected, considering the social and economic situation in the Levant at this stage, with its increasing international contact (Marcus 2002, 241), and the

cladistics analysis might actually point out areas of considerable homoplasy in the form of horizontal transmission as hybridization and parallel development. These phenomena of blending traditions are just as relevant as branching patterns to the evolution of material culture at this stage of cultural interaction in the Near East and we would simply be negating a large part of the creative input of any artist or crafts-(wo)men were we to neglect these transmitting mechanisms.

Looking at the evolution in a long-term perspective, within a geographical area of expanding and contracting cultural connections, we might consider a recurring pattern where what we call a ceramic tradition (culminating in an archaeological defined ‘ware’) starts out as a general heterogeneous group of ceramic vessels originating from different ceramic traditions sharing some features that have the potential of being widely transmitted and adopted; and this is especially the case in decorated ware. Yet, it is suggested that when such characteristics become entrenched in local ceramic practice, and result in higher output and more consistent patterns — as if they were a self-sustainable breeding population with humans as the transmitting agents — we might actually start recognizing more strict patterns of ‘descent with modification’ within groups of potters working together in a workshop setting. This suggests that we might focus on a particular range of vessels from Tell el-Dabʿa, where such a development of a consistent ceramic tradition can show more robust phylogenetic signals.

4.9: Case study 2: The introduction of juglet production at Tell el-Dabʿa

The Tell el-Yahudiya juglets from Tell el-Dabʿa form a crucial assemblage. Not only is it the largest and most complete assemblage from a single site, the nature and context of the juglets, found frequently in the tombs at the site, suggest the ceramics played a significant role in a particular cultural setting. Moreover, the assemblage shows developments that might be understood as key to the evolution of the Tell el-Yahudiya ware. Due to the nature of the site, and its pivotal position in the Eastern Mediterranean cultural interaction between Egypt and the Levant, it might be suggested that Tell el-Dabʿa is crucial in understanding the particularities of evolution of the Tell el-Yahudiya ware, especially those of the ‘Egyptian branch’ (see case study 1).

We took the piriform and biconical juglets as a second case study to focus on a particular group of vessels. This focus was taken because the link between the Levantine tradition and the Egyptian tradition is suggested to lie in the development of the piriform juglets (groups I and J). Moreover, the biconical juglets show many of the characteristics relating to the piriform juglets and it will be suggested they are closely linked to the evolution of the piriform juglets (the distinction is often blurred).

As we have seen, the use of the fast-wheel is still debated, however, a reconstruction of the *chaîne opératoire* of the juglets from Tell el-Dab'a would very much support the use of a fast wheel and the use of the technique to throw the juglets from the hump; where the vessel main vessel body is formed completely on the wheel. It is likely that this development took place in multiple ceramic workshops at Tell el-Dab'a, as the site grew in size and importance, and the juglets increased their crucial role in the funerary assemblage (Bietak 1991b; Forstner-Müller 2008; De Vreeze 2016a). Hence, the initial question is if a cladistics analysis of piriform and biconical juglets from Tell el-Dab'a, and selected other examples thought to be part of this evolutionary trend, show a branching pattern that might be in line with the suggested relative chronology of the site. Moreover, we can subsequently explore what the driving factors behind these changes were, and what selective pressure and technical choices were responsible for the change through time of these vessels.

4.9.1: The Taxa

Biconical or piriform

The taxa we chose relate to groups within the branches established by Aston and Bietak (2012) as taken over and refined from Kaplan's initial work (Kaplan 1980: a term of 'squat piriform' might define form between piriform and biconical: Aston 2004, 44). These broad definitions are retained as they remain the link to compare the results with the vessels in publication and no new nomenclature will be introduced at this stage. The taxa represent a variety of vessels within the biconical and piriform category (as defined above). This distinction is based on Kaplan's shape definitions but has been applied in a non-quantified verbal manner (§4.8.2). The juglets are defined as biconical or piriform without mathematical definitions but on the basis of the general appearance of the vessel shape. After Kaplan's publication, this is how the nomenclature is perpetuated in the archaeological literature. If we look at a graph

plotting the length and width of biconical and piriform juglets (mostly from Tell el-Dab^a) we can see that there is an overlap in what is called a biconical and piriform vessel where the biconical vessels L.4.1 and L.5.3 lie above the main cloud, due to the slightly bigger width relative to the height and L2.5 and L5.4 lie between the piriform and biconical cluster and is indeed seen as an intermediate group (Fig. 4.12).

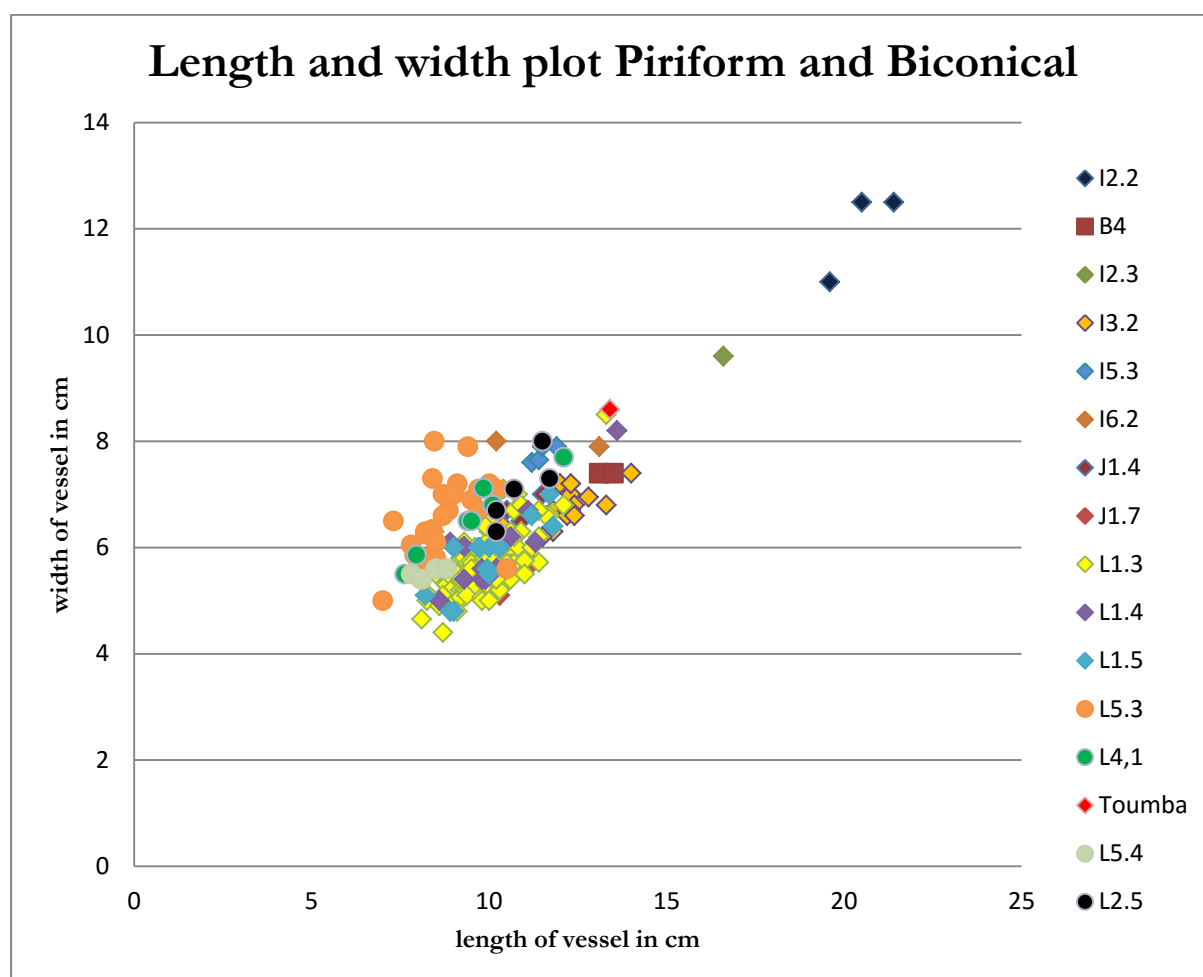


Fig. 4.12: Length and width plot of piriform and biconical vessel classes from Tell el-Dab^a (Aston and Bietak 2012a) and Toumba tou Skourou (Vermeule and Wolsky 1990) example (305 complete vessels in total).

From a technical perspective, this continuous factor is completely valid. If we suggest that the vessels were thrown off the hump, the difference lies in the initial stage of forming the vessel body (see Fig. 4.7, step 3) , where the potter pushes the wall slightly more outside and creates a carination that is midway the eventual body of the juglet, being slightly more pronounced in this way. The continuity between piriform and biconical shaped vessels might have been relatively fluid at one stage and the decision rather unconscious, whereas at a certain stage, the vessel form

becomes a conscious shape in the potter's mind, and was constructed deliberately, resulting in biconical vessels with a more pronounced width and sharper angles as the potter exemplifies these features (we would suspect the most consistent groups on the upper side of the cluster: L5.3, L5.4). This process needs to be evaluated in the future by mapping the continuity of these two shapes more rigidly. For now, we retain the distinction between piriform and biconical vessels, as can be recognized visually. We chose 35 taxa which were seen to be representing consistent types, either in frequency, or in technical choices made in their construction.

4.9.2: Outgroup

As an outgroup we chose three slightly different juglets from 'Afula, in order to get a wider basis of ancestral states from which derived characters can evolve. These three vessels are taken to represent the variety within the outgroup and are supposed to form most of the ancestral character states.

4.9.3: Ingroup

32 taxa remain in the ingroup. They represent the variety of piriform and biconical juglets, both known from the Egyptian-Levantine tradition (Aston group's I and J) and the Egyptian groups (Taxa L in case study 1). The taxa are both chosen on the basis of their relative frequency at Dab'sa, and on the fact that they are assumed to show relevant evolutionary character changes. Some of the juglets are thus unique but would relate to technical traditions with more flexibility (see above).

4.9.4: The Characters

32 characters were chosen and coded both sequentially (1-4) and binary (1,0 = presence/absence). The list consists of characters relating to the technical features of the juglets and relate to relating to technical choices on the shape of the body, the morphological characters of the separate vessel parts such as the mouth, handle and base, the decorative scheme, the decorative patterns and the decorative finishing techniques. A character defining the general surface colour was devised relating the firing-atmosphere (see **appendix 2** for the character list)

4.9.5: The analysis

A random heuristic search was conducted (§3.9.1). The heuristic search was chosen due to the large size of the matrix (35 taxa and 32 characters) with three vessels from

the 'Afula workshop taken as an outgroup. All characters are un-weighted and unordered.

4.9.6: The results

A large number of equally parsimonious trees were retrieved from the cladistics analysis. 65435 trees with an equal parsimonious length of 92 were found (22 characters are phylogenetically informative). These trees with a length of 92 have a CI of 0.5435 and a RI of 0.7754. The Retention Index of 0.7754 shows considerable support for branching and strong homology and is relatively high and in line with a phylogenetic pattern (Collard *et al.* 2006b, 177).

Thus, although the RI of these trees is significantly high 0.7754, the large number of taxa in the analysis leads to the possibility of slight alterations on the branches in the tree resulting in 65435 (exact number differs slightly for each heuristic search) trees of equal length and parsimony. These trees show slight differences in the branching patterns, each of which is equally parsimonious. In order to get an understanding of the dominant branching patterns, a strict consensus tree and a 50% majority-rule consensus tree were constructed (§3.9.3). Consensus trees collapse the branching pattern according to the relative occurrence. In the case of the strict consensus tree, only the bifurcations are shown that are supported by *all* the sampled trees. The other branches with less support are collapsed and result in nodes that represent multiple branches (instead of the usual bifurcation). With a (50%) majority consensus tree, only the branching patterns that occur in equal or over 50% of the 65435 equally parsimonious trees resulting from the cladistics analysis are shown. In this way the resulting trees show the nodes that have relative strong support and can be regarded as more robust and trustworthy. The 50% majority consensus tree thus shows branches that are not present in all the equally parsimonious trees, but are present in a majority of them, and hence the tree shows more detail on the evolution of the juglets.

4.9.7: 50 % Majority consensus

By default, the tree has a larger length (94) and lower CI (0.5319) and RI (0.7647). Yet these are still relatively high (especially the retention index of 0.76). Moreover the patterns in this tree can be seen as more robust. On the tree, the strength of the node is indicated (for instance 0.7) in which it occurs in the sampled (65435) trees.

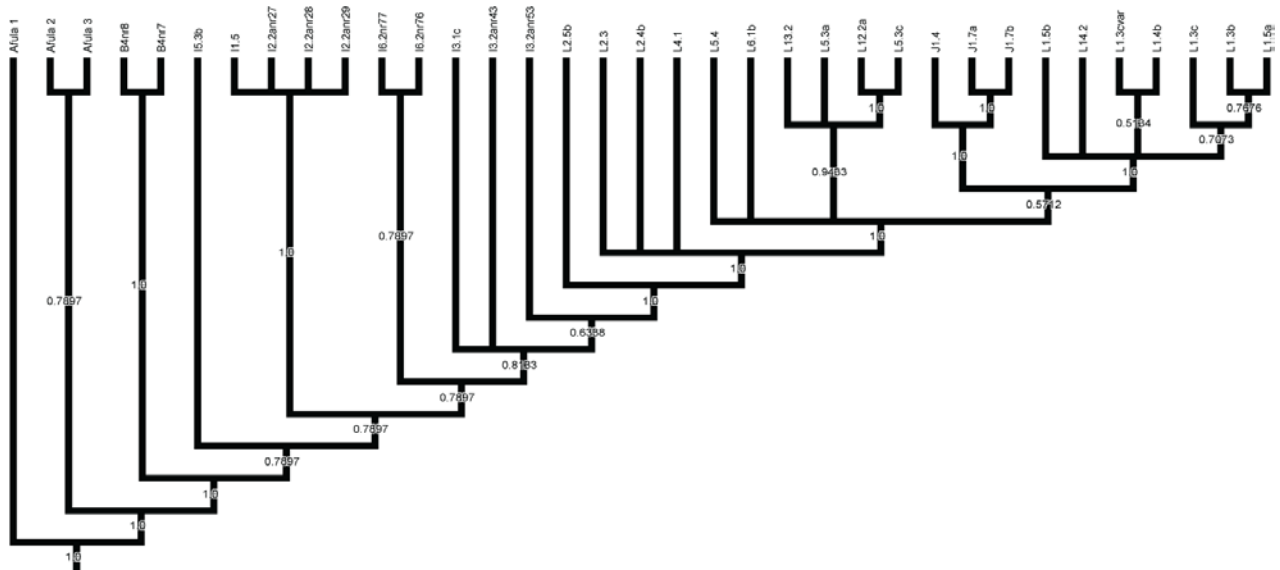


Fig. 4.13: 50% majority consensus tree of piriform and biconical juglets. The indexes show the occurrence of the clades in the total amount of most parsimonious trees (Maddison and Maddison 2011).

4.9.8: Strict consensus tree

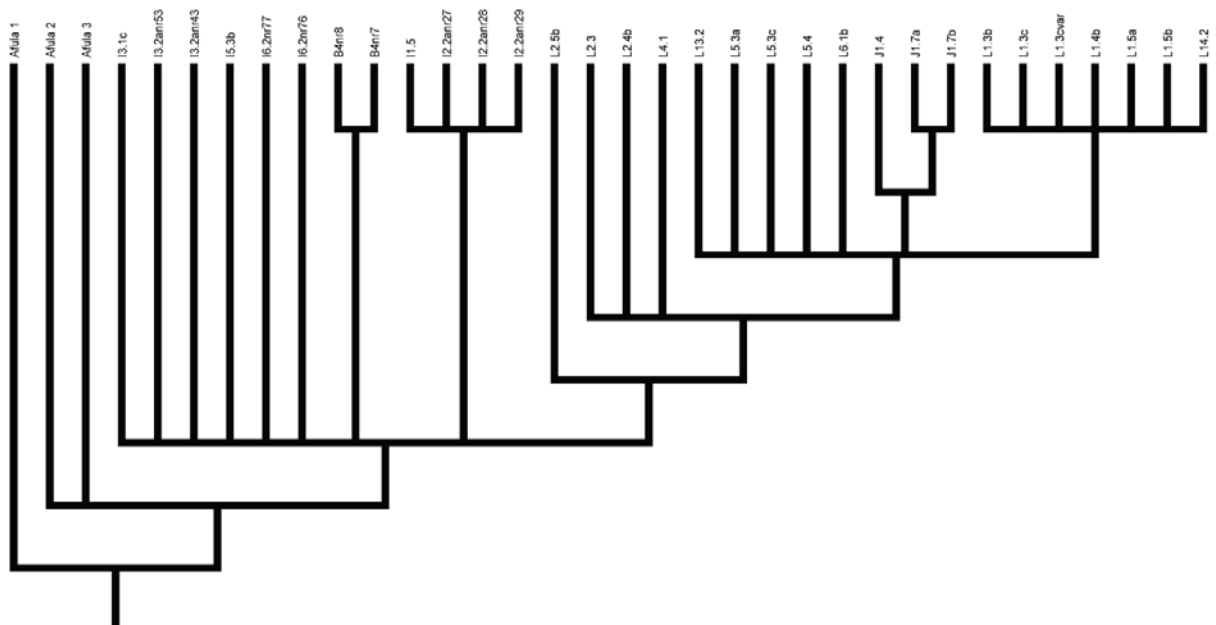


Fig. 4.14: Strict consensus tree of Piriform and biconical juglets. Length of 117, RI of 0.64 (Maddison and Maddison 2011).

If we construct a strict consensus tree of the 65435 equally parsimonious trees, this tree only shows the branching events that are supported in 100% of these sampled trees. The result is useful as it seems to distinguish the larger groups (see **Fig. 4.14**). The tree has a length of 117 (considerably longer due to multiple character changes), and the CI (0.4274) and RI (0.6417) are lower but still in line with phylogenetic data (Collard *et al.* 2006b, 177).

This sequence of branching shows the most robust branching events and nodes. A lot of the specific nodes are collapsed but there is still phylogenetic information on the relative branching events present. It is important to compare these trees with the stratigraphic data that is known for the Dab'sa juglets, to see if the relative sequence of branching reconstructed by cladistics analysis corresponds well to the perceived development in the stratigraphic phasing, and as such, the cladistics analysis might be seen as an independent check on the perceived change through time based on the stratigraphy.

Importantly, there is no guarantee that the 'right' tree is among the 65435 trees, yet the pattern of the consensus trees shows consistency that points to general evolutionary trends. Logically, a bootstrap analysis does not yield good supports for the node. With 65435 trees equally parsimonious, the amount of random possible trees with a slightly longer length is enormous and likely not to yield the same branching patterns.

4.9.9: Phylogenetic network results

The RI shows quite a strong branching pattern but the presence of reticulate data. A neighborNet analysis (**Fig. 4.15**) was performed on the same data. Interestingly, it shows that despite a netted pattern, there is considerable branching in the phylogenetic network as already indicated by the RI. The D-score of 0.297 and Q-Residual score of 0.06076 also indicate a fairly low degree of reticulation (**Table 4.11**) (Gray *et al.* 2010).

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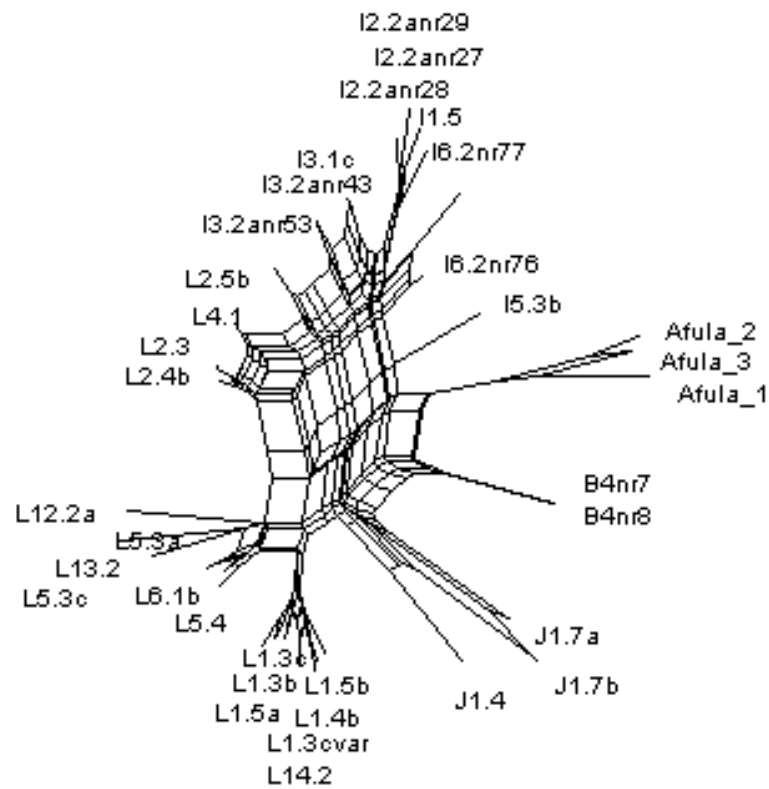


Fig. 4.15: showing a phylogenetic network using the same dataset. Interesting, despite the clear netted pattern (due to likely horizontal transmission of ceramic traits) the general shape still shows a branching pattern (analysis and image using NeighborNet).

Retention index	0.7754
D-score	0.2974
Q-Residual	0.06076

Table 4.11: The RI of the cladistic analysis tabulated with the D-score and Q-residual score of the network analysis. Both indicate quite strong reticulation.

1	50 % con	S T R I C T	H	G/ 4	G 1- 3		F	F- E3	E/ 3	E/ 3-2	E/ 2	E/ 2- E/ 1	E/ 1	E/ 1- D/ 3	D/ 3	D/ 3-2	D/ 2		
F/I			d/ 2	d/ 1	C	c/b 3	b/ 3	b/ 3- b/ 2	b/ 2	b/2 -1	b/ 1		b/1 - a/2		a/2				
#			1	2	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	?	T
Afula	1	1	?																
B.4	2	2					2											1	3
I.5.3b	3						3		1									1	5
I.1.5				1	1		2												4
I.2.2a					2		2	1	1										6
I.6.2									2										2
I.3.1c								1											1
I.3.2	4						1		15		2								18
L.2.5b c	5	3								1	1		2				1	1	6
L.2.3		4					1						3			1			5
L.2.4b								1					3		1				5
L.4.1								1		1	7	1	5					1	16
L.5.4	6	5											5				1	1	7
L.6.1b										1			1			1	6		9
L.13.2													1				3	4	8
L.5.3a											3	7			7			3	20
L.12.2										1			2		1	1	1		6
L.5.3c												1	4		13		1	1	20
J.1.4							3												3
J.1.7											2				1				3
L.1.5b	7	6									1	2	1	1	2	1	1	4	13
L.14.2											1		2		1				4
L.1.3cv ar													5		2				7
L.1.4b											1		5	1	2				9
L.1.3c											6	5	67	3	27	3	1	1	12 2 4
L.1.3b												3	19	2	7	1	1	5	38
L.1.5a													6		1				7
Total				1	3		14	4	19	2	23	15	13 8	7	65	8	16	3 4	34 9
%				0, 3	0,9		4, 7	1,1	5, 4	0,6	5, 6	4,3	39, 5	2,7	19, 6	2,3	4, 6	9, 7	

Table 4.12: juglets as analysed in cladistics by stratigraphic phasing of Tell el-Dab^a. The grey shading indicates the rough relative frequency. The red shading of Taxa I.1.5, I.2.2a and J.1.4 illustrates their ‘problematic’ stratigraphic occurrence compared to the branching pattern of the reconstructed tree. Numbers in red indicate juglets with uncertain stratigraphic positioning (as indicated by Aston and Bietak 2012).

4.10: Discussion

With the 50% majority consensus tree, we see that from the 'Afula outgroup, the cladistics analysis suggests the initial branching of is the clade with the B (early Palestinian) vessels (and imported to Dab'a). The table (4.12) with the distribution of these vessels in the Dab'a phasing shows that the juglets of B4 (which are produced outside of Dab'a in the Levant) occur relatively late in phase F, whereas juglets that branch off later in the 50% consensus tree occur earlier in the stratigraphy. An explanation of this discrepancy might lie in that the cladistics analysis actually shows a true pattern where the B4 juglets produced in Palestine branch off earlier from the 'Afula outgroup but only occur as imports at Dab'a slightly later, perhaps related to the strict stratigraphic system used at Dab'a.

Subsequently juglets belonging to the 'Branch I' branch off, which are seen as the Levanto-Egyptian tradition that encompasses the northern Levant, Egypt and Cyprus. In the case of the strict consensus tree, the relationship between the B taxa and I taxa is less resolved. The I taxa incorporate juglets that are characterised by inverted rims (folded inside), double handles, and design patterns incorporating multiple frames and motifs of triangles in different configurations, rectangles and zigzag patterns. It is suggested that the transition lies with a juglet of type I.3.2, which shows an inverted rim, double handle, double frame with standing and pendant triangles, and button base (of varying shape) (**Fig. 4.16**). On the basis of the stratigraphy and the above suggested reconstruction of the *chaîne opératoire*, it is during this phase of branching that a local industry of wheel-thrown juglets arises that will influence the further evolution of the juglets at Tell el-Dab'a, and subsequently in the rest of the Eastern Mediterranean. We suggest that the juglet I.3.2 is the crucial type that heralds this local production, which is in accord with the statement from the excavators at Dab'a that this form may have been produced in a single workshop (Aston and Bietak 2012a, 169). It is after the introduction of the fast wheel throwing technique and producing the juglets off the hump that this punctuated equilibrium occurred (as seen in **Figs. 4.7** and **Fig. 4.16**). In evolutionary terms, this phase is crucial and according to the stratigraphy would occur around phase E/3 at Tell el-Dab'a, though experiments with this way of producing the vessels might have occurred already in phase F according to the occurrence of these vessels in this earlier phase.

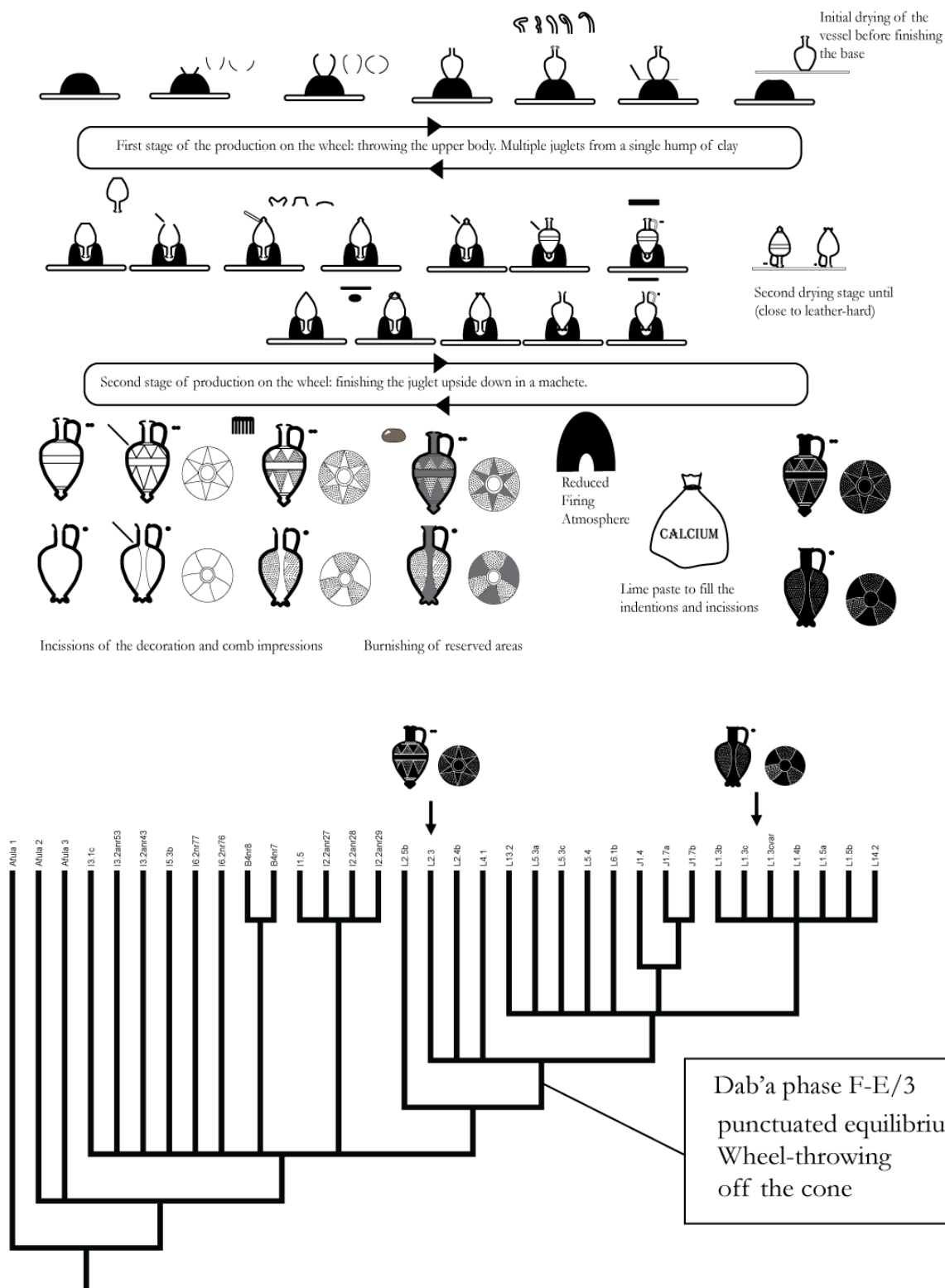


Fig. 4.16: the process of producing the juglets on a fast wheel and throwing off the hump can be seen as leading to a 'punctuated equilibrium' in evolutionary terms, it can explain a large number of changes in the characters ('simplification') and characterizes the production at Dab'a that dominates the 'Egyptian group'. The first juglet is an example of type I.3.2, the second juglet an example of L.1.3.

In terms of evolutionary development, we might see this moment as a punctuated equilibrium, where after a learning curve gaining experience with wheel-throwing, production reached a state where it was applied consistently and formalised in the *chaîne opératoire* of throwing a vessel, heavily influencing the evolution of the juglets at Tell el-Dab'a from then on (**Fig. 4.16**). In the cladistic reconstruction of both the 50% majority rule and strict consensus tree, the subsequent branch contains the 'L' taxa, that are both biconical and piriform, but share developments in characters. In general, there is a simplification in rim (everted-everted and folded) and handle (single strand instead of double strand). The change to a single handle might perhaps be explained by the fact that vessels were no longer formed by coiling (§4.5.1). The bases vary considerably, and from a technical point of view, this might be explained by the multiple choices and equal ease the potter has when finishing the base when the juglet is upside down on the wheel (see **Fig. 4.7 & 4.16**). Significantly, the decoration is simplified by incorporating fewer steps. The incised lines at the base and neck disappear, and the horizontal lines defining the frames are no longer incised at a later stage as well. The indented decoration is applied with a comb (multiple teeth varying in number) and the orientation of the decoration shifts from horizontal frames to vertical frames. This last step might be explained by the disappearance of the frame defining lines, where the motif of an upstanding and pendant triangle was simplified by incising a single vertical 'lozenge' and filling it with combing. This yielded one of the most ubiquitous juglet forms found at Dab'a (L.1.3: see **Table 4.12**). With the biconical juglets, the last stage can be seen in the production of vessels that yield comb decoration in continuous striations across the body, where the vessels are no longer fired under a reduced atmosphere, producing a lighter surface colour, and where the incisions are not filled by lime and the vessels (Taxa L.13). Yet in the cladistics analysis this taxa branches off at an earlier stage than expected from the stratigraphic information.

4.11: Discussion of general results

The phylogenetic analyses does seem to yield the general patterns in the evolution of piriform and biconical juglets, whilst the individual branching events of taxa of juglet types remains unresolved at times. In all likelihood horizontal transmission in the way of copying other potter's work still plays a role, as shown in the reticulation of the phylogenetic network, but now within single workshops or between multiple

workshops operating at Tell el-Dabʿa (single site spatial scale). Unfortunately we have no real idea of the actual number of workshops producing vessels at the site, and no traces have been excavated as yet. What becomes clear is that there is a loss of variety, of characters in morphology and foremost in terms of decoration after the punctuated equilibrium of the fast-wheel production (around phase E/3). The fact that phylogenetic studies show this development is very important and characterised the formation of the ‘Egyptian branch’ of Tell el-Yahudiya ware. It explains why in case study 1, we can set this branch apart. A parallel development to the one attested in the ‘Egyptian branch’ in character loss can be seen in the Southern Levantine tradition of producing the vessels (rims everted, single handles: case study 1) though it is hypothesized that this development did not have the same volume of production as witnessed at Tell el-Dabʿa. It can be suggested that in the latter case, potters were partly following the example of Delta developments, thus relating to different selective processes (adaptation to new fashions instead of adaptation in terms of speeding up production).

4.11.1: Piriform and biconical juglets and knowledge transmission by Levantine Potters

To test this assumption of the transmission of a type of wheel throwing production from the Northern Levant to the Delta, a number of juglets was chosen for phylogenetic analysis of which NAA and Petrographic studies suggest the location of production. These studies suggest that one of the key transitional types (I.3.2) occurs at Rishon le Zion, Ashkelon (both Southern Levant), and Tell el-Dabʿa with a petrographic signature pointing to the Lebanese coast (Cohen-Weinberger 2008, 114-115). It can be suggested that the local Palestinian tradition (with Jericho as a main exponent) is not involved in this development, and shows a markedly localised tradition. This would be reflected in the fact that Tell el-Yahudiya juglets show a different pattern in the local burial tradition. At Jericho, they never make up a dominant proportion of vessels in a funerary deposit, forming 4% of the total number of juglets, with maximum 28% in one tomb (Kenyon 1960; Kenyon 1965: Jericho See **appendix 4**), whereas at Tell el-Dabʿa, they can be deposited in large numbers in a single tomb (Föstner-Muller 2008; Bietak 1991b).

4.12: Case study 3: “a Cypriote ancestor”?

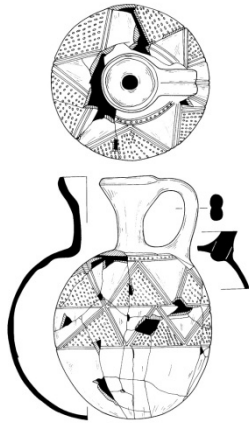


Fig 4.17: globular juglet with push-through handle (after: Aston and Bietak 2012, 532, Plate 118: 656)

The third level of analysis operates at the smallest scale, that of an individual or small number of individuals who might have migrated from Cyprus to Tell el-Dab^ʿa in the Early Middle Bronze Age, started to work at Dab^ʿa (at least part-time as a potter) and introduced a new type of juglet in the Tell el-Yahudiya tradition. The earliest examples of these juglets are found in graves dated to phase G 1/3 (Aston and Bietak 2012; see **Table 4.13**). Conventionally this phase is dated to around 1770 BC but it might actually be closer to 1900 cal BC on the basis of C-14 dates (see discussion §4.14.1) At this time, Tell el-Dab^ʿa was a busy harbour town which started to grow as trade was expanding to novel areas of commercial growth, particularly contact with Cyprus which grew as an international trading partner because it had large copper resources (Knapp 1985; Knapp and Kassianidou 2008; Knapp 2013).

The presence of Cypriote influence was picked up by the excavators of Tell el-Dab^ʿa mostly by the presence of a distinguishing feature: the push-through handle, where a handle is inserted through the body of the vessel, a technique which dominates the Cypriote ceramic industry (Maguire 2009, 21: see **Fig. 4.17**). This technique was ancient at Cyprus. What is significant is that this feature is a technical decision which is invisible on the outside of the vessel (and so to a consumer), but also not apparent to a potter who did not learn this tradition within a Cypriote context of training, especially in vessels with a constricted neck, such as juglets. In this regard, the character is less likely to be copied by other ceramic traditions (§2.4.9). Since the clay

of these vessels is local to the Delta (Fabric I-d) (Aston and Bietak 2012b, 534: Plate 119), and with a combination of decorative techniques applied to these early vessels that are reminiscent of Cypriote decorative styles (Maguire 2012), it is very likely that these technical features represent the presence of a Cypriote person or someone with a background in Cypriote potting was producing these vessels at Dab^a. It might thus be hypothesized that a Cypriote potter gave rise to a new tradition of vessel making at Tell el-Dab^a, or at least started a tradition in the fabrication of a type of globular shaped juglet that was taken over in the local ceramic tradition. An alternative hypothesis would suggest that the influence of imported Cypriote globular vessels gave rise to a ‘copy’ of the form in Tell el-Yahudiya style produced in Egypt. If the first theory is correct, we would expect a cladistics analysis that corroborates the general development of these globular juglets at the site based on their relative position in the phasing of the site, and the character development to show a certain technological logic.

4.12.1: Methodology: Taxa

The hypothesis is that a Cypriote potter or small group of Cypriote potters introduced a new type of juglet with a globular form at Tell el-Dab^a. When scanning the Cypriote ancestral candidates proposed by Maguire and Aston and Bietak (Bietak 1996, 59; Maguire 2009, 23), no real ancestors could be found that were represented in a single vessel or small group of vessels (as hypothesized for the ‘Afula group). Interestingly though, Maguire suggests the decorative pattern was most in line with the painted decoration occurring in traditions typical for the Northwest of Cyprus (Maguire 2009; 2012). Fragments of the design can be found in White Painted Ware and Black Slipped traditions (Åström 1957). At this stage, an early vessel displaying clear Cypriote traditions from Tell el-Dab^a was chosen as an outgroup (Aston and Bietak 2012b, 534: Plate 119). In this regard, an alternative (future) approach would be to construct an amalgam outgroup of Cypriote character traits defined by typical ceramic traditions used on the island. The assumption for our cladistics analysis is that the branching pattern that occurs from this ancestor would correspond well with the sequence of the vessels as related to the Dab^a stratigraphy and show a development expected on the basis of previous suggested typological developments.

4.12.2: Taxa

Taxa were chosen that are thought to represent the Cypriote tradition. This group was largely represented by group N: handmade globular juglets, defined by Aston and Bietak (Aston and Bietak 2012, 302). Next to these handmade globular vessels, we used the other globular vessels that were found at Tell el-Dab^a and hypothesized to have developed from these handmade globular ones (Group L.9).

Seventeen taxa were devised (comprising 115 vessels, 65 of which are from Tell el-Dab^a) (see **appendix 3**), some of which represented vessels with unique traits, and others which formed a larger group (L9.4 and L9.5). Already it can be seen that the handmade Cypriote style vessels display more unique singular features, and the later wheel-made globular juglets have more frequent occurrence. The taxa are almost all present at Dab^a, save for group L9.5 (with un-delineated decoration) which is expected to be a fairly late development which is generally less well presented at Dab^a but can be seen at nearby Tell el-Yahudiya, the upper Egyptian site of Edfu, 2nd cataract stronghold of Buhen, and Enkomi (Kaplan 1980; database).

4.12.3: Characters

The first character defined the vessels as handmade or wheel-made. This was done using the descriptions in the dataset of the Dab^a juglets. The handmade vessels might have been partly moulded or drawn up by hand, the neck often shows signs of having been inserted separately (overlapping walls: Bietak and Aston 2012; see **Fig 4.16**). The exact mode of production of the wheel-made globular juglets is not known. We might assume that they first formed a rounded bottom and then finished the vessel on the wheel, or they closed the base upside down (a more complex method making use of centrifugal force). The drawings and descriptions do not allow any conclusions on this point.

The globular juglets were divided into two main groups by size. The plot of the width and length of the vessels can be shown in the graph below (**Fig. 4.18**). Two basic sizes were chosen on the basis of perceived clusters in size: 1) Length < 7 cm, width < 4 cm, 2) Length = > 7 cm and a width => 5 cm. All the globular juglets from Tell el-Dab^a are between 4 and 13 cm in length. The division is based on the known assemblage of juglets and the upper limits of the juglet sizes can extend to juglets with a length of 13-16 and width around 9-10 cm (Enkomi/Cyprus and Tell el-

Yahudiya). It might be significant that the L9.5 juglets from Kaplan's dataset (nr. 35, from sites such as Tell el-Yahudiya, Edfu and Buhen) range considerably in size and include the largest examples. The largest examples from Enkomi and Tell el-Yahudiya show that the selective pressure of size might have been smaller outside of Tell el-Dab^a.

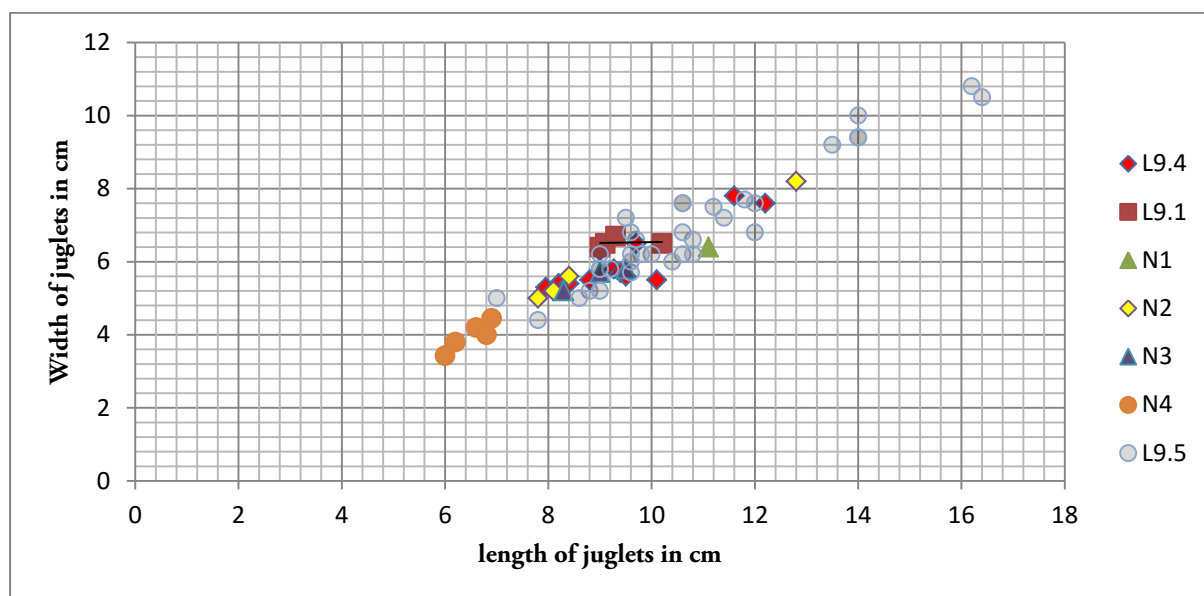


Fig. 4.18: a plot of the length and width of the globular juglets. It can be seen that there is a continuous linear line and considerable overlap. The only group that stands out considerably is the N4 group of handmade globular vessels. (nr of vessels: 68).

The characters chosen again relate to the technical features of forming the vessel and decorating it (**appendix 3**). 19 characters were coded relating to morphology: with multiple states for size (two states) the rim (4 states), handle shape (4 states), push-through handle (2 states), decoration: lines down the body underneath the handle (3 states), lines incised at transition neck and body (2 states), and decorative designs (9-19: 2 states). These characters are summarized in appendix 3.

4.12.4: Outgroup

As an outgroup, we chose a type of vessel that was handmade, displayed Cypriote characters and occurred earliest in the Dab^a phasing: N.2.1b (1 examples from G/1-3, 1 from E/3: Aston and Bietak 2012, 531-532, Plate 112). The characters of the complete and larger vessel of this group (Dab^a excavation number 4158) were taken as the outgroup.

4.12.5: Ingroup

The ingroup consisted of the 19 other vessel types, both representing the handmade globular vessels in Group N, and wheel-made globular vessels L.9.4a and L.9.5. The difference between the globular juglets L.9.4 and L.9.5 is the fact that the latter does not have the comb impressed area delineated by incised lines (Bietak and Aston 2012, 257).

4.12.6: Results

The cladistic analysis, using a branch-and-bound search in PAUP (Swofford 2002), yields three equally parsimonious trees with a length of 35. These trees have a CI of 0.6129 and a RI of 0.7551 which is relatively high and shows support for a branching pattern (compare data Collard *et al* 2006, 177). The tree is shown in **Fig. 4.19**, with images of the juglets at the end of the branches. At first sight, a development is clear in the evolution of the decoration that develops from the elaborate Cypriote style into the standing and pendant triangles and ends with lozenges. As we will suggest below, the latter stage is in parallel with other *vessel shapes* and might indicate a parallel development, however, the selective pressure for these decorative changes might foremost lie in the production of piriform juglets, and copied with other vessel shapes at Tell el-Dab^a.

A bootstrap analysis (10,000 repetitions) shows support of 74% for the clade of N1 and N2.1c, 68% for the clade with L9.1b and L9.1b, 64% for the clade with L9.4a and L9.5 and 66% for the clade of L9.1a and b, L9.4a, L9.5 and L10. The other branching events do not show stronger support than 50%. The lack of support for these other nodes might again be explained by the presence of homoplasy in the dataset. If we use the boundary of 70% to indicate a reliable clade, only the clade of N1 and N2.1c would be reliable, with the other clades showing supports of 64, 66 and 68% being on the boundary (Tehrani and Collard 2009, 293; Hillis and Bull 1993). As remarked previously, bootstrapping can be a rather strict method and should be used here as a relative indication of robustness of the tree.

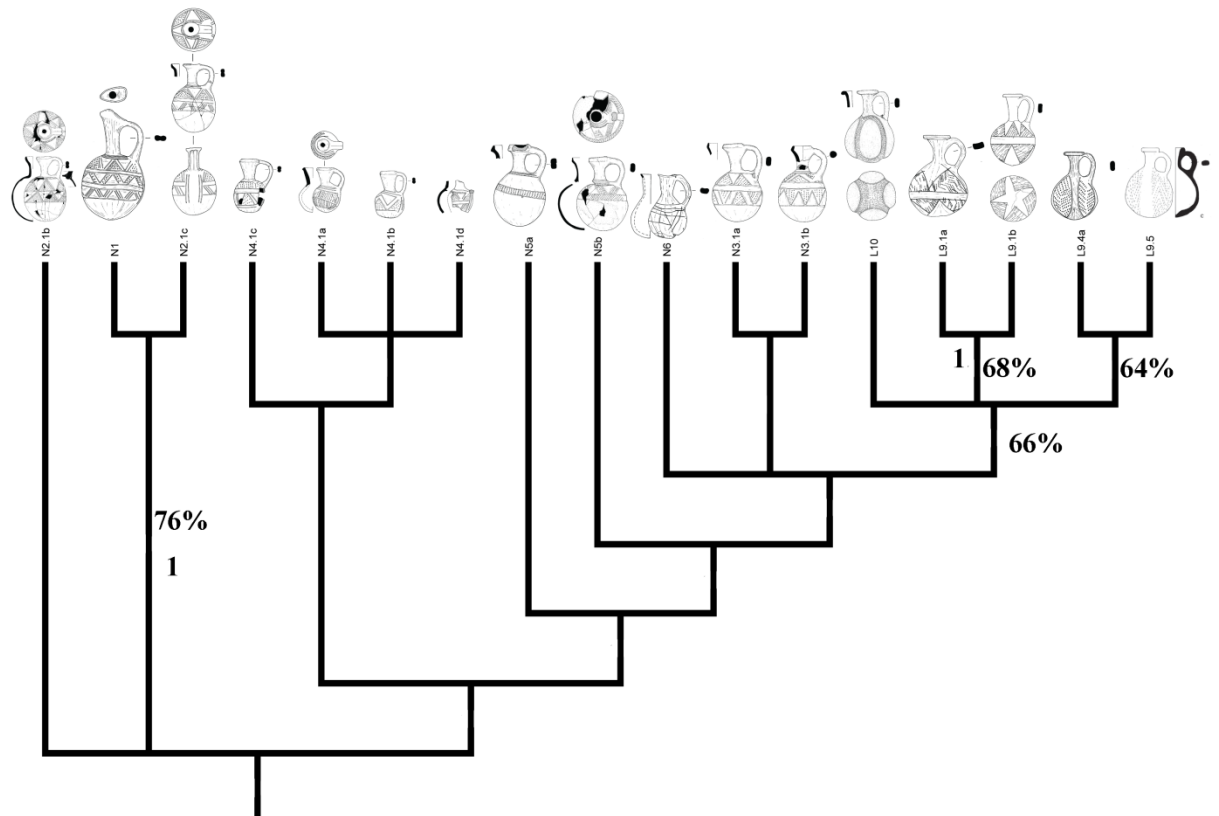


Fig. 4.19: cladistics reconstruction of globular juglets. The bootstrap support and Bremer steps are shown. (Juglets after Aston and Bietak 2012: not to scale).

We conducted the Bremer test to get another idea of the robustness of the branches. The Bremer test yielded a support 1 step for the clades of N1-N2.1c and L9.1a-b. This in itself is not incredibly strong, and it signifies that with a length of only 1 more steps, the branching pattern is not as strongly defined.

The RI of 0.7551 in itself would suggest strong support for a phylogenetic signal in the data and would in itself indicate that the pattern of descent with modification from a common ancestor is dominant. Yet the bootstrap analysis does not show an overall strong support for the branching pattern, especially if we use the 70% boundary as stated above.

To test if the cladistics reconstruction is indeed a viable option, it is interesting to look at the presence of the juglets in the different phases to see if they corroborate the cladistics reconstruction. If we consider the distribution of the juglets throughout the phases of we can see the following (**Table 4.13**).

Globular juglet types and the phases. The numerical period represents a continuous sequence of phases																			
Phase	Per	N 2. 1b	N 1	N2. 1c	N4. 1c	N4. 1a	N4. 1b	N4. 1d	N5a	N 5b	N 6	N3. 1a	N3. 1b	L10	L9.1 a	L9.1 b	L9.4 a	L9.5	T
H	1																		0
G/4	2																		0
G/1-3	3	1		2					1										5
	3.5											1							1
F	4			1		1			1	1		4	2						10
	4.5			1		1													2
E/3	5	1	1	1	1		2	1	1			1							9
	5.5																		0
E/2	6					1					1								2
	6.5															2			2
E/1	7													2	3		16		21
	7.5																1		1
D/3	8															1	2	1	4
	8.5																		0
D/2	9																2		2
?																2	4	1	6
T		2	1	5	1	3	2	1	3	1	1	6	2	2	3	5	25	2	66

Table 4.13: the cladistics analysis and the occurrence of the vessels throughout the Dab^a phases.

4.12.7: Discussion

The distribution throughout the phases shows a roughly congruent pattern with the sequence in branching, where in general we can observe a ‘seriation’ that starts with the Cypriote style vessels (group N) and ends with the wheel-made globular vessels decorated with lozenges (character trait 18: L9.4 and L9.5). The evolutionary pattern would indeed suggest a pattern that sees the development of wheel-turned juglets from handmade ancestors, everted rims following inverted (kettle rims), handles that go from double to single stranded, decoration that uses more complex incisions and patterns towards decoration with single incised triangles and later on lozenges, ending in comb impressed lozenges not delineated by incised lines. These patterns would be suspected on the basis of previous research and seriations provided by Aston and

Bietak (2012). Yet there seems to be a ‘break’ between the ‘N’ branch and ‘L’ branch around phase E/2. This break is important as it might show that if transmission was via potters sharing knowledge, we are left with a chronological gap. Alternatively it might point to a chronological break between the phases which is unrecognized. If the transmission went through the potter adapting traits from an observed vessel (with larger agency for the vessel copied), this could explain the gap. However, there is a problem with this in that the dividing line that seems to be around phase E/2 (period 5-5,5-6) or E/2-1 (period 6.5), because as mentioned before, doubt can be cast on the archaeological reality of ‘stratigraphic’ phase E/2 (phases E/2 and E/1 are also grouped together when radiocarbon dates are considered). This division around phase E/2 might thus be seen as a discontinuation, where these two traditions of vessel making must be seen as separate. This could possibly be reflected in the low bootstrap supports for some of these earlier branching nodes. However, considering the high RI of the cladistics analysis and the overall conformity of the data, we might suggest the analysis supports a hypothesis.

Another issue is that some inconsistencies occur if we consider the stratigraphy to be indicative of the first occurrence of vessels that seem to be branching relatively ‘later’ on the reconstructed tree. In this sense, the juglets of type N3, N5 and N6 should be branching off earlier with N3.1a-b offering relative strong evidence for their appearance in phase F (period 4).

In all, it is important to ask what the transmitting mechanism would be from this early handmade Cypriote tradition into a globular wheel-made one. Would it represent a vertical transmission of a younger generation of potters taking over this globular shape by learning it from an older (Cypriote) potter? It is more likely that the globular juglet became an established type earlier with types N.3.1 for instance, which were contemporary with some of the ‘Cypriote’ ones but show no push-through handle and Cypriote decorative patterns. It is likely that at the stage of phase F-E/3, this transmission took place, perhaps within a single workshop as a locus of communal practice. After phase E/3, this Cypriote tradition is no longer attested. It might be that the Cypriote potter stopped working (in the Tell el-Yahudiya tradition), or started working in a tradition more akin to the local Dab’a one. Another option is that the potter(s) working around the time of Phase F-E/3 moved back home to Cyprus.

The length of the phases becomes relevant again, because if we take the phases to represent a length of 30 years each, Phase G/1-3 to E/3 would comprise a period of 90 years max, or 30 years minimally end of G/1-3, beginning of E/3 = phase F). If the juglets occur over a period of 90 years, and actually represent the production of such juglets over this length of time (thus not being heirlooms), it is unlikely that the Cypriote tradition represents a single generation. However, if we see the phases G/1-3, F and E/3 as shorter or actually partly overlapping, the period of a Cypriote potter working at Dab'a might actually be significantly shorter. It might be that the juglets represent a fairly short episode, namely the presence of a Cypriote-born individual who worked as a potter at Tell el-Dab'a for a short while around 1800 BC.

In this context, it becomes interesting to see where these juglets displaying Cypriote features were actually found. If we look at the context of the juglets, it turns out that often juglets with Cypriote features occur in a single tomb (**Table 4.13**).

Database #	Ex #	phase	Grave	Interred person	type	Tomb published
669	1771	F	A/II-m/10 planum 6 burial 8	Burial 1: Young female (17-21Y)	N3.1b	Bietak 1991, 67, Abb. 34.7
670	1781	F	A/II-m/10 planum 6 burial 8	Burial 2: Adult female (30-50Y).	N3.1b	Bietak 1991, 67, Abb. 34.5
660	1782	F	A/II-m/10 planum 6 grave 8		N2.1c	Bietak 1991, 67, Abb. 34.6
676	1850	E/3	A/II-n/13 planum 6-7 grave 8	Badly preserved: Young female (16-18?).	N4.1c	Bietak 1991, 91, Abb. 48.2
675	1851	E/3	A/II-n/13 planum 6-7 grave 8		N4.1b	Bietak 1991, 91, Abb. 48.3
674	1849	E/3	A/II-n/13 planum 6-7 grave 8		N4.1b	Bietak 1991, 91, Abb. 48.1
682	8856	E/2	A/II-p/14 grave 2	Neonate	N6	Bietak and Aston, plates 123, 143; Forstner-Müller 2008, 238
673	8856A	E/2	A/II-p/14 grave 2		N4.1a	Bietak and Aston, plate 122
662	8819A	E/3	A/II-p/14 locus	Infant	N2.1c	Forstner-Müller

			286 grave 13			2008, 216, Abb. 136.4
654	8698	E/3	A/II-p/14 locus 286 grave 13		N1	Fortner-Müller 2008, 216; Abb. 136.5
655	7486F	F?	A/IV-h/4 grave 11	<i>Unknown</i>	N2.1a	Bietak and Aston, plate 118
668	7486C	F?	A/IV-h/4 grave 11		N3.1a	Bietak and Aston, plate 121
672	7486	F?	A/IV-h/4 grave 11		N4.1a	Bietak and Aston, plate 122
667	7486E	F?	A/IV-h/4 grave 11		N3.1a	Bietak and Aston, plates 121, 141
659	4167	c	F/I-i/22 grave 34	<i>Unknown</i>	N2.1c	Bietak and Aston, plate 119
656	4168	c	F/I-i/22 grave 34		N2.1b	Bietak and Aston, plates 118, 140
665	6053	b/3	F/I-o/21 grave 5	<i>Unknown</i>	N3.1a	Bietak and Aston, plate 120
680	6042	b/3	F/I-o/21 grave 5		N5	Bietak and Aston, plates 123, 143

Table 4.14: Multiple handmade globular juglets in single tombs (after Aston and Bietak 2012)

The fact that multiple instances of handmade globular juglets turned up in single burial contexts would suggest that they were acquired from the same source and very likely at the same time. It is plausible to suggest that these juglets were produced specifically for funerary rites at Tell el-Dab'a. We can speculate on the link between the potter and the interred. It would take too far to identify the interred as having a necessary link with the 'Cypriote' potter or identity. What might be more likely is that a person (man or woman) versed in the 'Cypriote way' of making pots migrated to Tell el-Dab'a (around phase G/1-3) and produced vessels in small quantities to be sold to participants in the funerary rites. It might be that a tradition of Cypriote pottery making survived at the site due to Cypriote immigrants teaching the craft within their family. The role of novices (both adults and children) in Bronze Age ceramic making on Cyprus has recently been discussed in similar ways (Gagné 2014). In this regard it

might have been a part-time activity in which there was an opportunity to sell the juglets, in a 'Tell el-Yahudiya' decorative style, popular for the funerary rites.

4.12.8: Conclusion on the Cypriote potter and evolution of globular Tell el-Yahudiya juglets

What is likely is that a single or few people migrated from Cyprus to Tell el-Dab'a during the 12th Dynasty (phase G/1-3) when Tell el-Dab'a was a relatively small settlement. These people might have come in the capacity of sailors, full-time potters, or even wives; this is open to speculation. The cladistics analysis yields a most parsimonious consensus tree that is more or less in accord with the development of globular juglets at Tell el-Dab'a. In itself the relative sequence of branching could support the idea that these locally produced Cypriote style globular juglets developed into wheel-made globular juglets, after which the developments displayed many similarities with piriform and biconical juglets (homoplasy) (case study 2). The transmission of the idea of a 'globular juglet' might have originated in these Cypriote vessels, yet the transmission mechanism is harder to ascertain. It might have been in the form of a 'Cypriote potter' working at Dab'a and introducing the shape, or based on the copying of imported Cypriote globular juglets.

4.13: Conclusion and discussion on Tell el-Yahudiya evolution

What preliminary conclusion might we draw from these case-studies? It seems relevant to take into consideration the spatial and temporal scales of transmission, which relate to groups of potters working in geographically dispersed areas, workshops operating at a single site, and individuals that initiate new traditions. Different selective mechanisms play a role relating to these different spatio-temporal levels. On all three levels, the cladistics analysis has not yielded evolutionary reconstructions that are fully supported by homology, indicating that on all three levels, homoplasy plays a role. The role of homoplasy, in the form of hybridization of traditions and parallel development seems most pertinent in the case study, incorporating taxa that represent general groups of ceramic practice in the Levant.

At this level, we might suggest that the idea of Tell el-Yahudiya as a distinctive 'ware' is misleading, and although dispersed traditions seem to gain some unity under a single field of approaches in decorative techniques, the underlying ceramic traditions are quite diverse. In terms of a 'ceramic ware' the Egyptian tradition,

dominated by the production at Tell el-Dab'a, could be called a proper ware in terms of having a rather standardized practise of producing ceramics with a large output. This was mostly advocated by the second case study that seems to indicate that around phase E/3 a punctuated equilibrium in producing these juglets on the wheel occurs that sees the onset of wheel-thrown juglets produced off the hump, resulting in this standardization and the loss of variability in characters (simplification of technical actions).

On the level of individual potters, we have tried to test the hypothesis that a Cypriote potter might have been the ancestor of the globular juglet as produced at Tell el-Dab'a, and although the cladistics analysis is not unequivocal, it suggests that this evolutionary pattern is not implausible, but issues with the way of transmitting knowledge remains.

The results of the phylogenetic analysis might suggest that in general we see a pattern where the amount of hybridization is reflected in the RI and a reticulate pattern in phylogenetic networks. It is significant that 'descent with modification' is most robust in a situation of 'standardization' as witnessed in the juglets produced in the Nile Delta, hypothesized to be foremost at the site of Tell el-Dab'a/ Avaris itself, which poses questions as to the dominant selective pressure. Does this pattern show that, as the ceramic industry becomes more 'standardized', the transmission process might be seen as more vertical and showing 'descent with modification'? This would be in line with the theory that wheel-throwing involves a substantial period of apprenticeship and introduces clear pattern in descent with modification when speeding up production (§2.3.4) It seems that when we infer phylogenetic links between small scale geographically constricted ceramic fabrication (local workshops) only a small part of the change through time is explained by 'descent with modification' within the overall 'Tell el-Yahudiya' framework. The expectation would be that if we would compare the *chaîne opératoire* of the output a single workshop or group of potters (if they could be located spatially and geographically) the phylogenetic signal would be larger than for these spatially and geographically separated ceramic industries.

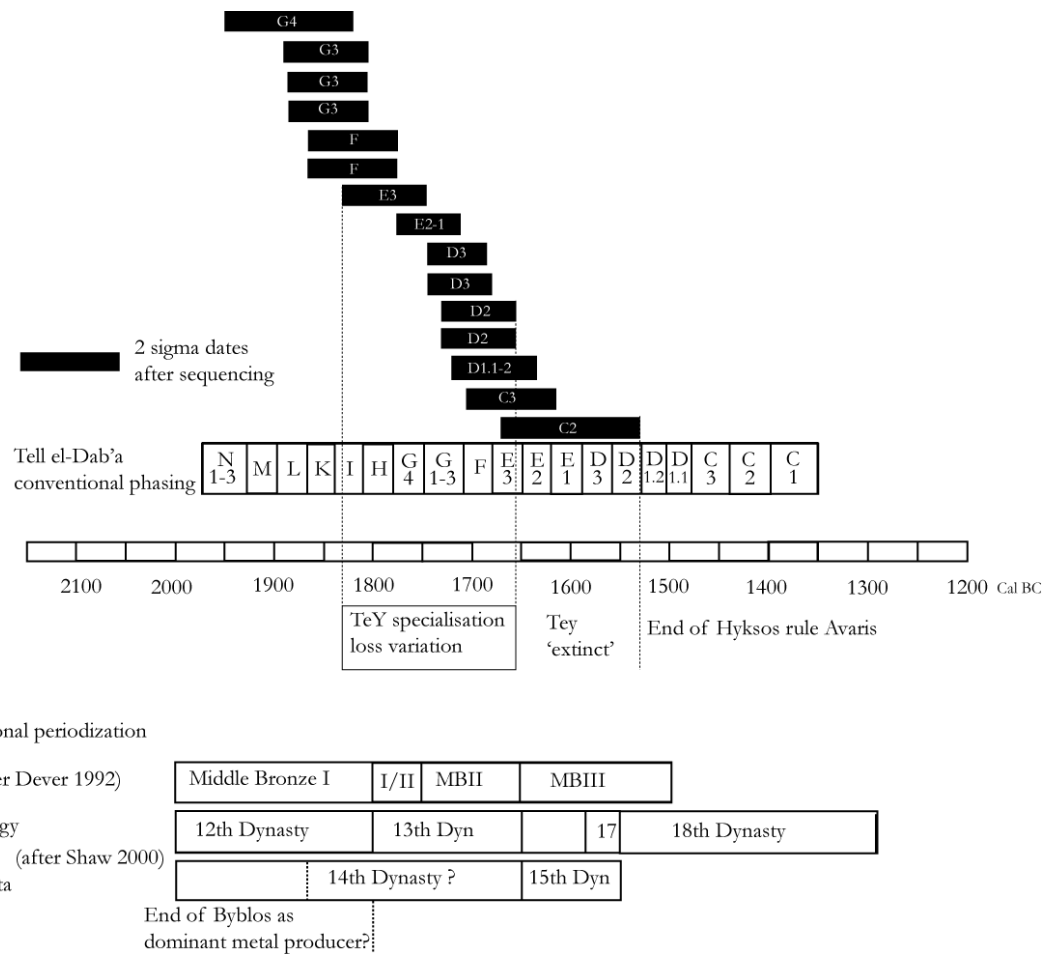


Fig. 4.20: Adapted from Wiener (2006). It shows the conventional dating of the Levantine Bronze Age (after Dever 1992, and the conventional dates of the Egyptian dynasties (after Shaw 2000). If we accept the C-14 dates (in black) this should shift our perception of the phasing and historical dating (Hyksos rule until end phase C2) and Tell el-Yahudiya were going 'extinct' already during the 15th Dynasty rule at Dab'a.

In terms of selective pressure, we might suggest that a combination of a punctuated equilibrium in juglet production at Tell el-Dab'a, combined with a cultural niche of the use of these juglets in funerary rites, and a large demand for such juglets because of these funerary rites resulted in selective pressure being put on the production process (see discussion chapter 7). The technical possibility of producing these juglets in a more standardized serial way lead to the simplification of the *chaîne opératoire* where there is loss in diversity of morphological characters and decorative techniques that leads to simplification. It seems that these character changes were irreversible in a cultural sense (though not technically), as there was no reversal to more complex decorative patterns at a later stage. This poses the following question: might this development in itself be seen as responsible for the disappearance of Tell

el-Yahudiya juglets as a distinctive ware at Tell el-Dab'a (and the general Levantine context)? One could suggest that a new range of juglets was introduced during the SIP which 'took over' the role of Tell el-Yahudiya ware; the large number of Cypriote imports could be a good example of this (Maguire 2009, Steel 2013, see below and discussion chapter 7). The late group of 'Tell el-Yahudiya ware' juglets which were often no longer fired under reduced conditions and with a combed instead of incised surface, might be suggested to be this latest stage.

Considering the discrepancy in dating the Dab'a phases, an important pattern might be observed (**Fig. 4.20** above). If the radiometric dates are compared with the phasing of Tell el-Dab'a, the dates would shift back around 100-120 years (see §4.3.5). This would have consequences for assigning phases to certain cultural-political developments. Phases F/E3 would mark the perceived change from the Middle Bronze I to II in the Levant, and the onset of the Second Intermediate Period when Egypt which had been unified under the 12th Dynasty Middle Kingdom broke up in smaller local Dynasties. This would coincide with the period (around 1800 BC) where production of the juglets takes on another magnitude at Tell el-Dab'a (Kutschera *et al.* 2012, 416: Figure 6a places it around 1800 cal BC). Yet this change in production, with the associated loss of variability in characters and simplification of the production chain, together with a dominant niche for the juglets as funerary gifts, might have resulted in a 'precarious' situation that was prone to extinction. Traditionally, this period is equated with phases E/1-D/2 and the rule under the 15th Dynasty of the Hyksos from the capital Avaris (Tell el-Dab'a). Yet with the C-14 dates suggesting a chronological shift, these phases would fall within the preceding (obscure) 14th Dynasty, and the actual 15th Dynasty Hyksos rule would coincide with Dab'a phases D/1-C/2.

This would mean that Tell el-Yahudiya ware had ceased to be produced at Tell el-Dab'a *before* the height of Hyksos rule, and should not be equated with the 15th Dynasty, which would have severe implications for our perception of chronology and relations between ceramics and cultural identity. We might suggest that the process set in motion after the punctuated equilibrium, with simplification and a particular niche for use, left the Tell el-Yahudiya ware prone to extinction, particularly when there was heavy competition from other juglet categories such as increased Cypriote

and Aegean imports, a phenomenon that is usually associated with the onset of the Late Bronze Age (Maguire 2009; Steel 2013).

This possibility would not only lead to important questions on chronology, but also relating to the cultural meaning of these juglets in Egypt and the Levant. Were these juglets perceived to be Egyptian, or connected to Hyksos identity? In biological terms it is suggested that extinction is diversity-dependent, and environment – dependent, with the risk of extinction increasing when diversity of *species* increases, and especially with *environmental* changes (Grant and Grant 2008, 126). In juglet terms, the extinction of Tell el-Yahudiya juglets might be associated with increasing competition from imported juglets that filled the same niche, and a cultural environment that was becoming more influenced by the imports from the Aegean region and Cyprus at the end of the Middle Bronze Age and start of the Late Bronze Age (Maguire 2009; Steel 2013), together with a local production that was ‘dead-locked’ in a process of simplification of technical actions in its *chaîne opératoire*. Traditionally, this process is associated with the onset of the 18th Dynasty in Egypt and the start of the Late Bronze Age in the Levant (around 1550 BC). But we might suggest that this process was actually facilitated during the 15th Dynasty of the Hyksos, who might not be seen as distinctively ‘Semitic’ and connected to the southern Levant, but had a pronounced orientation across the Mediterranean, to Cyprus and the Aegean.

4.13.1: Fragrant funerals?

It hard to quantify mortality in ancient times, but at least one scholar has hinted that mortality could be quite high in the deltaic town of Dab^sa; as Broodbank states (2013: 376): “A town in this kind of environment may have bred death as much as it encouraged life, negating any increase in well-being and so needing a constant influx of population to sustain itself.” With a maximum size of 250 ha, this in itself would suggest the existence of a ceramic ‘industry’ concerned with supplying offerings for the dead. With an estimated population in the late Middle Bronze Age/SIP of 25,000-40,000 people for this site alone (Broodbank 2013, 384; Bietak 1996), local potters – and intermediate traders – would thus be catering to a sizeable population interring their dead firstly within the walled confines of mortuary temples, and later in burials under house floors (Bietak 2010b). Among the vessels interred with the dead, juglets, and Tell el-Yahudiya juglets in particular, form a key component of grave gifts for

men, woman and children (Bietak 1991b; Forstner-Müller 2008; Forstner-Müller 2010).

The role of juglets and small containers in the Eastern Mediterranean has been strongly connected to fragrant oils and perfumes in the Late Bronze Age (1550-1200 BC) (Steel 2013, 131-138). The distribution of Cypriote juglets (termed precious commodity containers by Maguire) throughout the Eastern Mediterranean suggests the operation of similar principles in the Middle Bronze Age (Steel 2013, 131; Maguire 2009). Vessel shape and decoration has even been associated with 'commodity branding', almost being associated with product placement, and signalling different unguents (Bevan 2010; Bushnell 2013). Although actual fragrances are hard to ascertain archaeologically, it can be convincingly argued that the sharing of fragrant oils and unguents have deep Bronze Age roots going even further back than the examples we have from the Middle and Late Bronze Age. The general shape of its ideal container, the juglet, can be clearly recognized in Early Bronze Age ceramic industries, and is for instance attested in EB II-III burials at Jericho (Kenyon 1960; Chesson 2015, 69: Fig. 5). Steel (2013: 128; 132) uses Late Bronze Age Mycenaean pottery and Cypriote ceramics to argue for the importance of unguents and perfumed goods which were transported across the Mediterranean and formed part of elaborate gifts.

Known ancient locations for producing perfumes and unguents are still rare, but a recently reported reputed 'perfumery' at Pyrgos/Mavroraki dating to around 2000 BC, being part of a small workshop area also including metallurgy, seems to provide good hints towards such production on a small industrial scale (Belgiorno 2009: although the exact nature of the contents, beside reported olive oil, awaits further publication). Mycenaean texts from Pylos have offered crucial insights into the Aegean perfume production (Shelmerdine 1985). From Egypt, multiple scenes of flower gathering and production of perfumes and unguents are known from Middle Kingdom tombs, however most of the imagery dates to the New Kingdom (Shimy 1997; Shimy 2003). A wide range of different oils are mentioned in Egyptian texts from the 1st Dynasty onwards, including perfumed oils from 'Kaphtor' (identified with Crete) and 'Alasiya' (which can be identified with Cyprus) (Shimy 1997, 144: *huile-nkftr de Sangar* (Crete); 157: *huile-dft d'Alasia* (Cyprus)). Recent studies by Andrew Bevan and Lesley Bushnell have forcefully argued for the presence of clear product branding

signalled by particular ceramic types distributed through the Eastern Mediterranean, and Tell el-Yahudiya ware would have been part of such a development (Bevan 2010; Bushnell 2013). It is thus very likely that certain types of oils were associated with particular locations and cultural practices within the Middle Bronze Age world. Moreover, scents would likely play an evocative role in creating long-lasting memories of certain situations and places such as funerary rites (Moeran 2007; Hoover 2010). The likelihood that the use of oil could be linked to status, identity or even ethnicity is beautifully illustrated when we read between the lines of *the Tale of Sinuhe* set at his long-awaited final return to Egypt:

“The years were made to pass from my limbs; I became clean-shaven, and my hair was combed. A load was given back to the foreign country, and clothes back to the Sand-farers. I was clad in fine linen; I was anointed with fine oil. I slept in a bed. I returned the sand to those who are upon it and the tree oil to those smeared with it.” (Parkinson 1997, 42)

Here then, we have a clear indirect reference to the cultural difference in coiffure (including shaving), clothing (linen instead of wool)¹³, and significantly, the different use of fine (perhaps fragrant) oils. The ‘tree oil’ could either refer to olive oil or oil extracted from the seeds of the *Moringa* tree, known as ‘Ben-oil’ (Marcus 2002; Shimy 1997, 251; Shimy 2003). We can only guess what ‘fine oil’ was used, a plethora of spices and floral extract could have been used, of which the white lily and blue lotus certainly were popular. Thus, fragrant oil provides one of the key elements to illustrate the difference between the Egyptians and Levantine population (sand-farers or more widely attested as *Retjenu/Retinu*). Being an early Middle Kingdom text, it also reminds us that fine oil was likely produced within Egypt at this time, making the local manufacture of Tell el-Yahudiya juglets – an original Levantine product - likely to be filled with locally produced scents. This adds to the idea of particular eastern ‘Delta’ meanings attributed to these vessels.

4.13.2: Symbolic evolution and the reference to ‘Lotus’ and ‘Lily’ in Tell el-Yahudiya vessels

As an illustration of the meaning which might be conveyed in decorating Tell el-Yahudiya vessels, and its relation to the evolution of decoration we can analyse the motif of the ‘lotus’ or ‘lily’. The fragrant connection discussed above brings us to an

¹³ The difference between fine linen from Egypt and colourful wools from the Levant, Anatolia, Mesopotamia and the Aegean is attested to by Broodbank (2013).

important element of the decorative evolution of Tell el-Yahudiya juglets which might have been slightly overlooked so far. Numerous flowers were used in preparing perfumed oils (Shimy 1997; Shimy 2003). Well known are the blue and white lotus (or more correctly: water-Lily: *Nymphaea caerulea* and *Nymphaea lotus*) featuring richly in Egyptian iconography and mythology, with the blue lily being associated with the birth of life (Jensen 2012). Moreover, the lily (*Lilium candidum*) is at home in the Eastern Mediterranean, and can be recognized on some vessels and was also popular for making perfume. These flowers form important motifs on earlier Tell el-Yahudiya juglets, often in combination with (aquatic) birds. It can be suggested that the recurring iconography of ‘aquatic’ scenes, fowl and particularly the lotus (either blue or white lotus) had particular resonance for Egyptian ‘delta-dwellers’, referring to a cultural ‘deltaic’ background. However, both the blue and white lotus, and even more particularly the lily (*Lilium candidum*) are known to occur in the Levant, the latter most specifically from Lebanon (Feinbrun-Dothan 1986, 44). It is thus likely that these fragrant flowers were highly appreciated for making perfumed oils in both regions; a connection visible in these early Yahudiya vessels.

In this sense, one stylistic development attested on Tell el-Yahudiya juglets is of particular interest in this discussion, as it suggests that the meaning conveyed in the design might have become more abstracted but remains present in the design of Tell el-Yahudiya juglets. A crucial development is seen around phase E/1-E/2 at the conjunction with the ‘punctuated equilibrium’ addressed before (§4.2). At this stage, the motif of the lily seems to have become more abstracted, but perhaps still intrinsically inferred within this abstracted design. Juglets of type I.3 (**Fig. 4.21**) show an upper and lower panel with incised triangles pointing upwards and downwards. When looking at the top of the juglet, or from the bottom, when pouring liquid, these would look like an opening (lotus) flower. These juglets, at the pivot of the punctuated equilibrium, might be seen as giving the last tentative hint towards its possible contents, as after this stage, the steps in speeding up the decoration lead to further abstraction leaving the decorative reference beyond the point of floral recognition.

It can thus be suggested that the image of lotus and lily might at one point have been a quite direct reference to the contents of these vessels and represent an early case of product ‘branding’ alluded to for juglets in general by other authors (§4.13.1;

above).¹⁴ However, it is equally likely that the blue and white lotus on Tell el-Yahudiya juglets had an even deeper significance in the Nile Delta. Lilies and lotuses are well attested in iconography and actual preserved plant remains of these flowers formed a crucial part of festivities and funerary garments (Hepper 1990, 9; Woenig 1897, 70-71). They must have formed an integral part of the funerary pyres and burned offerings which were associated with the burial rites at Tell el-Dab'a (Bietak 1991b; Müller 2008).¹⁵ As such, the presence of lotus flowers on rare Tell el-Yahudiya style beakers from a pit deposit (Locus 81) showing a striking assemblage of vessels for consumption, along with animal remains dominated by cattle and sheep/goat but also pig, hare, birds, turtle and fish remains in lesser frequencies (Aston *et al.* 2009, 70-72: Table 4), and likely reflect the left overs of such large scale festivities in association with a palace (Aston *et al.* 2009). This context is exceptional, in showing quite a large amount of Tell el-Yahudiya vessels (48 fragments) including juglets (with lotus/Lily motif), and unique vessels such as a bovid decorated in the same style (Aston *et al.* 2009; Aston and Bietak 2012) (**Fig. 4.21:7-8**). Such large scale feasts often, but not exclusively, connected with funerary practices were by no means exclusive to the eastern Delta or Egypt, as recent evidence from Sidon suggests very similar practices in Northern Levant (Doumet-Serhal 2001), as does evidence from Hazor and Kabri (Maron *et al.* 2014).

Here it becomes significant that the blue lotus (*Nymphaea caerulea*), in particular, has been argued to have been used for its psychoactive effect, where the petals and roots could be mixed with drinks such including wine (Aretxabaleta 2001; Bertol *et al.* 2004; Emboden 1978; Emboden 1989; Harer 1985).¹⁶ If blue lotus was indeed used in this way one can imagine that the beakers with this lotus decoration in 'Tell el-Yahudiya style' might have contained such a concoction: drinks (likely wine) imbued with blue lotus flower (petals and roots) for added effect.

¹⁴ Future residue analysis, when able to distinguish particular flowers, might give final resolve into this question. For now lipid analysis does not seem to warrant such detailed identification.

¹⁵ With its clear aquatic connection in the Delta on the Pelusiac branch of the Nile, its architecturally attested ponds and gardens (Bietak 2010, 10), including temple gardens with tombs in Area A/II, it is highly likely that Tell el-Dab'a itself had the necessary 'botanical gardens' (Shimy 2003, 31) and a sizeable perfume industry catering to local and foreign markets, which the potters producing juglets catered for directly. This might await further archaeological discovery.

¹⁶ The experiment of imbuing wine with the blue lily formed part of a popularized televised show from 1998 researched and presented by the late Andrew Sherratt (Sacred Weeds Part 4: <https://www.youtube.com/watch?v=Vx2AIBgnakI>).



Fig. 4.21: The lotus or lily features on early Tell el-Yahudiya juglets can be seen as a form of ‘branding’ and evolves showing a steady decorative simplification (1-4). It can be argued that at some point (juglet 4) the hint to one of its significant contents (lotus or lily perfumed oil) was only as a symbolic reference. (Images 1: juglet from Toumba tou Skourou: Negbi 1978; 2: juglet from Ashkelon: Stager and Voss 2012, 569: Fig. 5.32; 3: Aston and Bietak 2012, plate 12.47 4: Aston and Bietak 2012, 408: Plate 44.220, 5: Antique perfume lotus perfume bottle from Egypt, 6: Image of *Nymphaea caerulea* (courtesy Pintarest); 7-8: Aston and Bietak 2012, 544: Plate 125.696 and 698; Images not to scale).

The consumption of such goods would perhaps occur mostly in the context of what Sherratt has called ‘ritual inversions’, for instance at festivities or funerals (Sherratt 1995, 16). The practice of mixing wine with spices and herbs is suggested to have been pinpointed archaeologically in a recently excavated ‘wine cellar’ at Middle Bronze Age Kabri. Here, complete storage jars were found and analysed for residues according to the authors suggesting the presence of tartaric acids (wine) being imbued with additives such as cedar oil, cypress, juniper, and perhaps spices such as cinnamon, myrtle, and mint (Koh *et al.* 2014). If the results are indeed correctly interpreted, these results start lifting the veil on remains of spices, drinks and edible goods already alluded to in textual sources but having remained archaeologically elusive until the advance of residue analysis. There is no reason to exclude the mixing of lotus with drinks as a recipe used already in the Middle Bronze Age, together with its use in perfumed oils, and forming part of the Eastern Mediterranean cultural exchange.

Concluding, there are numerous symbolic messages which might underlie and influence the decoration, as illustrated for the Tell el-Yahudiya vessels. If indeed these symbolic references to lotus, lily and aquatic birds are connected with Egypt and the Nile Delta in particular, we may ask what the role of potters was who produced juglets bearing these motifs outside of Egypt proper, most likely in the Northern Levant (Cohen-Weinberger 2008). Some of the vessels bearing ‘Nilotic’ scenes are almost certainly not produced in the Delta at this stage (Cohen-Weinberger 2008; Stager and Voss 2012). It would thus seem that in this hybrid world, these juglets and their contents were appreciated in both regions, but adding a layer of complexity, as it suggests Levantine potters were already catering to a ‘foreign’ market during the Middle Kingdom, producing vessels with iconography fitting the demand of these eastern Deltaic and Nilotic consumers. The same pattern has already been suggested for the subsequent Late Bronze Age Eastern Mediterranean pottery production, where certain Mycenaean (and Cypriote) vessels were clearly produced for foreign consumption (Steel 2013, 134). The same principle can be seen in ‘chinaware’ which was produced for European consumption which could be labelled as ‘commodities by destination’ (Appadurai 1986b; Steel 2013, 134).

Having ended the discussion at some of the more symbolic aspects of decorative evolution of Tell el-Yahudiya ware, we will come back to discuss the implications of

these insights in chapter 7. For the time being, we will stay in the 2nd millennium BC, but move from the Eastern Mediterranean to south-east Arabia, as it is time to delve into the second main research topic in this thesis: the evolution of Wadi Suq ceramics.

Chapter 5

The Evolution of Wadi Suq ceramics

5.1: Introduction: The Wadi Suq period

For the second millennium in south-east Arabia, ceramic development has also been voiced in terms of evolution, as the quotes below illustrate:

“The evolution through time of some artefact categories, notably pottery, was established and we are now certain that at least some sites were settled throughout the second millennium BC...” (Cleuziou and Tosi 2007, 186-187).

Cleuziou and Tosi suggest here that ceramic data has been crucial in establishing a periodization which shows a particular cultural development. However, Carter suggests that:

“... the inability of archaeologists to distinguish stylistic evolution in ceramics and softstone during the first half of the second millennium may be indicative of stylistic conservatism...” (Carter 1997a, 106).

Here, Carter uses ‘evolution’ mainly as a metaphor for diversity in the ceramic record and suggests that ‘stylistic conservatism’ can be attributed to 1) decreasing population numbers in the Wadi Suq relative to the preceding period, and 2) high mobility of the population (Carter 1997a, 106), making it hard to recognize cultural differences at the start of the 2nd millennium BC. In this chapter we will address this ceramic evolution during the first half of the 2nd millennium BC in south-east Arabia with the help of more specific evolutionary methodologies.

5.1.1: The ‘Wadi Suq’ period

The cultural period we chiefly concern ourselves with in this chapter spans a period of roughly 2000 BC to 1600 BC (Velde 2003, 102; Magee 2014). It overlaps chronologically with our first case study of Tell el-Yahudiya juglets (Chapter 4), yet relates to a distinctly different geographical area and archaeological record which consequently shows the potential for markedly different cultural trajectories. The period of concern is called the ‘Wadi Suq’ (WS) period after a Wadi in the foothills behind Sohar (Wadi Jizzi/Wadi Suq) in present day Oman, where Karen Frifelt

excavated a number of tombs in the seventies yielding a hitherto unknown style of painted pottery (Velde 2003, 102; Frifelt 1975). With the crystallization of cultural periods in the archaeology of this area, the tombs at this site subsequently gave name to a newly defined period that followed the Umm an-Nar period; that is the start of the 2nd millennium BC. The term ‘Wadi Suq’ for this cultural period was popularized after an early synthesizing article by Serge Cleuziou on the Oman Peninsula, based on these tombs and their material culture, together with archaeological remains from the recently excavated site of Hili 8 (Cleuziou 1981; Velde 2003, 102). It is noteworthy that although Cleuziou explicitly starts his paper stating his intent *not* to use the Wadi Suq as a common cultural denominator, and rather speaks of the ‘early 2nd millennium BC culture of the Oman Peninsula’, exactly the opposite happened after the publication of his article (Cleuziou 1981, 279). Ever since, the term ‘Wadi Suq’ has grown into an archaeologically recognized period seen as markedly different from the preceding Umm an-Nar period (2500-2000 BC). Such distinctions between archaeological periods often cause problems when ‘cultural boundaries’ turn out to be quite permeable.

The following, arguably more neutrally termed ‘Late Bronze Age’ would commence around 1600 BC and last until 1300/ 1250 BC (Magee 2014, 182; Velde 2003, 102). This period has long been included within the Wadi Suq period by scholars such as Carter, Potts and Vogt (Carter 1997a; Potts 1990a; Vogt 1998) (see **Table 5.1**). The discussion about adequate names already stresses the issue of artificial cultural boundaries drawn by researchers’ desire to fit the archaeological record into neatly defined chronological periods. However, some form of continuity between both the Umm an-Nar and Wadi Suq period on the one hand, and Wadi Suq and Late Bronze Age on the other has been widely recognized by the previous mentioned authors and would suggest that as quite often, these clearly demarcated cultural periods have to be taken as a general framework with fuzzy boundaries. In fact, Cleuziou - among others - has argued for dropping the more heavily loaded terms of Umm an-Nar and Wadi Suq and has advocated a more neutral Early, Middle and Late Bronze Age (Cleuziou 2002).

These general divisions within the Bronze Age would be more in line with the practice in surrounding countries (most notably the Northern and Southern Levant, though not in Mesopotamia). Nevertheless, although I basically agree with a more

neutral nomenclature that avoids using names derived from type-sites which are afterwards often found out to be ill fitting - the same problem features in the term Tell el-Yahudiya ware in the first case study – this is not followed up here because most of the relevant literature continues to use the terms Umm an-Nar and Wadi Suq. As such, not using the term Wadi Suq would alienate archaeologists' perception of the discussion. More importantly, in terms of absolute chronology these periods still remain quite poorly anchored. Only with an improved set of C-14 dates from good 2nd millennium BC contexts which can provide an absolute chronological framework will the division in Bronze Ages be more neutral in the end. Yet as long as it is realised that denominations such as Umm an-Nar and Wadi Suq are necessarily partial and artificial, it is better to qualify the periods in more detail and stress the continuity and discontinuity between these archaeologically defined periods, while at the same time building up a stronger absolute chronology on the basis of C-14 dates.

5.2 Geographical extent: south-east Arabia

Cultural remains associated with the Wadi Suq, predominantly in the form of ceramics, tomb architecture and copper alloy finds, are found in an extensive area from al-Qusais close to modern-day Dubai, to Ghalilah (modern day Ras-al-Khaimah) close to the Musandam Peninsula in the north (**Fig 5.1**). The most southerly instance yet recorded seems to be from Masirah Island on the south-east coast of Oman (Cleuziou 1981; Vogt 1998; Weisgerber 1991).¹⁷ In general this extensive area is known as the Oman Peninsula, encompassing the modern United Arab Emirates and northern part of Sultanate of Oman (Cleuziou 2007, 227: note 1). In a recent extensive overview of Arabian prehistory, Peter Magee uses longer standing geographical divisions of the Arabian Peninsula into south-eastern, western and north-eastern Arabia. We will follow this division and thus our area of concern mainly encompasses south-east Arabia (Magee 2014).

¹⁷ An area approximately 680 km in length as the crow flies (from Masirah Island to Ghalilah). Unfortunately the material from Masirah remains scarcely published, for instance in an unpublished thesis by: Shanfari, A. H. 1987. *The Archaeology of Masirah Island, Sultanate of Oman*. [unpublished].

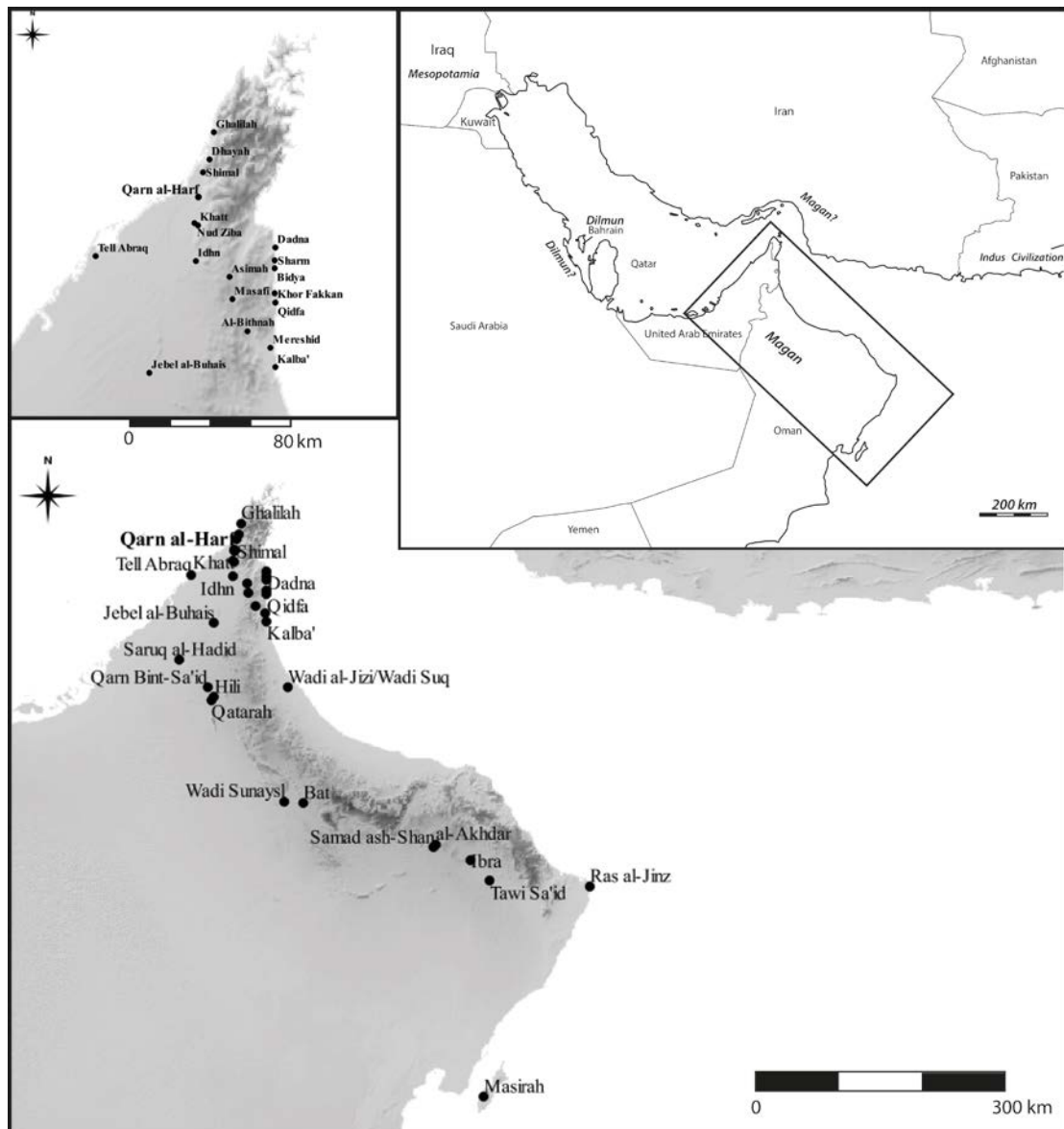


Fig. 5.1: Main of main sites with 2nd millennium BC Wadi Suq remains in south-east Arabia as mentioned in the text. Qarn al-Harf is located in the northern Emirates in the foothills of the Hajjar mountains (Basemap courtesy of NASA (90 m DEM). Map created in QGis 2.8.1).

5.2.1 South-east Arabia

The area of south-east Arabia lies between the eastern extremity of the Rub al-Khali, and the Oman Mountains, rising over 2000 m above sea level (Ru'us al Jibal to the north, and Hajjar mountains) (Goudie and Parker 2011, 109). This part of the Arabian Peninsula is marked by steep rise of the Hajjar mountains, a mountain range running from the Musandam peninsula south-east towards the Ras al-Hadd peninsula in Oman (Goudie and Parker 2011; Magee 2014, 15). Presently, the area is marked by an arid to hyper-arid climate (Goudie and Parker 2011, 109). The Hajjar mountain range,

with a complex history of geological formation, yields important resources exploited in the Bronze Age such as the ophiolite deposits harbouring crucial copper deposits, and soft-stone, as well as the weathered clay beds used for making pottery (Magee 2014, 16). Some of the key sites for the Wadi Suq lie in the foothills of these mountains, and a large number of the tombs, often monumental in nature, consisting of subterranean or above ground stone-built tombs with different lay-outs, form the bulk of structural evidence from this period (see further below), can be found concentrated along the alluvial plains at the foot of this mountain range, the tombs of Qarn al-Harf and Shimal being among the most prominent concentrations known to date. *Wadis* cutting their way at various points through these mountains provide important transit routes from the interior of the peninsula to the north eastern coast. (Carter 1997a, 15-29).

The alluvial plains running from the foot of the Hajjar mountain range are ‘bounded to the south and west by the Rub al-Khali’ with its northern extension running into the Emirates of Ras al-Khaimah (Magee 2014, 18). On the east side of the al-Hajjar mountain range, in modern day Oman, a narrow alluvial plain, between 15 km and 45 km wide and 240 km long¹⁸ known as the Batinah, stretches from Dibba in the north to Muscat in the south east, and in modern times is seen as the agricultural ‘heartland’ of Oman (Magee 2014, 23). Until recently this fertile area was fairly underexplored in archaeological terms; it is now a focal area of renewed archaeological excavations and surveys, partly to do with an upsurge in recent building activities.

5.2.2 The Indian Ocean and Persian Gulf

Thus far we have offered a rather land-locked overview, but the coastal connection of the south-east of Arabia to the Indian Ocean has been crucial to its connections to contemporary cultures in India, Iran and Mesopotamia. Maritime activity in this area probably dates back as far as the Neolithic and has been a crucial component of history in the region (Carter 2006; Carter 2012; Pearson 2003). Important for the history of archaeology has been the traditional connection of this part of the Arabian Peninsula with the toponym ‘Magan’, which is attested in Mesopotamian sources of the 3rd millennium BC, and known to be a key provider of copper resources to

¹⁸ Information on extent of Batinah coast from Encyclopaedia Britannica
<http://global.britannica.com/EBchecked/topic/56022/Al-Batinah>

Mesopotamia (Cleuziou and Méry 2002; Cleuziou 2003; Magee 2014, 99; Weisgerber 1980, see **Fig. 5.1**). The location of Magan is commonly identified with south-east Arabia, however, parts of south-east Iran (the Makran coast especially) might well be incorporated in this general geographical denominator, which does not necessarily need to present an area of political unity, but perhaps one based on common practices and incorporation in the wider exchange system (contra Potts 1994, 35). Instead I agree with Thornton who suggests (2013: 613): “Instead, the region from Mesopotamia to Meluhha is better envisioned as a number of overlapping economic and cultural spheres of influence emanating from distinct and empowered polities of varying scales”.¹⁹ Archaeological studies of the north-eastern area (including Bahrain) at the end of the 3rd millennium and start of the 2nd millennium BC have started to show that after an incipient move towards complexity and hierarchical organization in the 2nd millennium BC, the area of Bahrain sees the emergence of Dilmun on the historical stage, with all the trappings of a state organization providing the main conduit of trade between Arabia and Mesopotamia (Carter 2003a; Magee 2014, 125; Terp Laursen 2009; Terp Laursen 2008). However, as will be noted below, the evidence from south-eastern Arabia suggests this movement towards social hierarchy seems to have been countered, and after some kind of collapse at the end of the Umm an-Nar period, the Wadi Suq period is currently seen to reflect movement toward regionalization, less sedentary sites, and social organization countering these inherited hierarchical tendencies (Magee 2014).

5.3: Periodization and fuzzy boundaries

As mentioned earlier, some discussion exists about the exact boundaries of archaeologically defined cultural periods. Most scholars still define a clear break between the 3rd and 2nd millennium BC. Significantly, Cleuziou recently suggests using the more neutral ‘Bronze Age’ continuous stages for the 3rd millennium BC, but still puts a clear break with the onset of the Wadi Suq period (Cleuziou 2002, 192). However, it may be suspected that with ongoing new results and material from late Umm an-Nar and Early Wadi Suq contexts, the ‘cultural boundary’ between the 3rd

¹⁹ The location of Magan and the influence of Mesopotamian textual sources which represent an ideal structured image of the world around the Persian Gulf is a topic worth exploring on its own. It is very likely that the unity of geographical locations such as Dilmun, Magan and Meluhha (Indus Valley) were in fact more complex, fuzzy and shifting borders.

and 2nd millennium BC — the Umm an-Nar and Wadi Suq — will start to show cracks and become more permeable as well.

General period	Period BC	Cleuziou 1981	Potts 1993	Carter 1997	Cleuziou 2002	Velde 2003	Magee 2014
Hafit	3000-2500	Hafit	Proto-historic B (2900-2300 BC)	Hafit	EBA stage 1 2,3,4,5	Hafit	Hafit
Umm an-Nar	2500-2000	Umm an-Nar	Early Historic A (2300-2000 BC)	Umm an-Nar		Umm an-Nar	Umm an-Nar
Wadi Suq	2000-1600	Wadi Suq	Early Historic B: 2000-1700; Early Historic C: 1700-1500 BC	Classic Wadi Suq	Wadi Suq	Wadi Suq 2000-1600	Wadi Suq
Late Bronze Age	1600-1300/1250	Wadi Suq	Early historic C and D: 1500-1200 BC	Late Wadi Suq	Wadi Suq	Late Bronze Age 1600-1250	Late Bronze Age

Table 5.1: summarizing the main chronological divisions used for south-east Arabia during the 3rd and 2nd millennium BC.

In the case of the 2nd millennium BC it is perhaps better to refrain from too detailed subdivisions at this point and stick to the general term Wadi Suq (2000-16/1500 BC), called Classic Wadi Suq by Carter (Carter 1997a; Carter 1997b) and Late Bronze Age (16/1500-1300 BC) for now (after Magee 2014).²⁰ This is for several reasons:

²⁰ A much more detailed subdivision is used by members of the Tell Abraq excavation, apparently based on stratigraphy at the site, separating the period into: Wadi Suq I (2000-1900 BC), Wadi Suq II

- 1) The absence of absolute dates from good stratigraphic contexts: we do not possess enough absolute dates for this period from clear stratigraphic contexts associated with good material cultural records to really pinpoint detailed chronological subdivision within the Wadi Suq period (see **Fig. 5.2**).
- 2) Regionalization: the sequence established at one site or region might not reflect the wider area of the Arabian peninsula (Potts 1993a, 167), and the same should apply to even smaller regions with general cultural terms such as the Wadi Suq actually covering a patchwork of regional versions of what we perceive to be a fairly common culture on the basis of its material cultural remains. We will discuss this issue further below, predominantly on the basis of ceramic data.
- 3) Fuzzy Boundaries: as will be stated repeatedly, conventional boundaries between archaeological periods are fuzzy. For example, subdivisions based on ceramic change do not need to map neatly on to sub divisions in the development of tomb architecture, as techniques and customs might change in different modes and tempos. Moreover, as yet, we possess too little information on how material cultural change reflects social change during the Wadi Suq period (De Vreeze 2016b), although establishing these links is crucial to our further understanding of the 2nd millennium BC in Eastern Arabia. For example, the boundary between Umm an-Nar and Wadi Suq around 2000 BC might differ depending on regional trajectories in terms of ceramic and metallurgic technology, tomb architecture, and settlement dynamics.

The more recent tendency is to see the period after 1700/1600 BC as distinct from the Wadi Suq period, mainly advocated by Christian Velde in a recent overview, and hence called the Late Bronze Age (Velde 2003). This more general designation seems to move towards further integration with Near Eastern chronology and practices of labelling the Bronze Ages as Early, Middle and Late, particularly as with Levantine Archaeology. However, Mesopotamian chronological periods are still very much subdivided by political rule. The use of general ‘Bronze Age’ periods in south-east Arabia could have the effect of bringing periods over a wider area of the Near East in

(1900-1600 BC, Wadi Suq III (1600-1400 BC and Wadi Suq IV (1400-1300 BC) (Barker 2002, 89: footnote 1). The WS III and IV would now be considered Late Bronze Age in date. However, no published record is presented to support this division and the distinction does not feature in the two reports on Tell Abraq (Potts xxx). However, the renewed excavations at Tell Abraq under the direction of Peter Magee are bound to yield significant results towards a better chronological framework, on the basis of stratigraphy, carbon fourteen dates, and material cultural development.

line in terms of terminology. This would make it easier for objective archaeological comparisons.

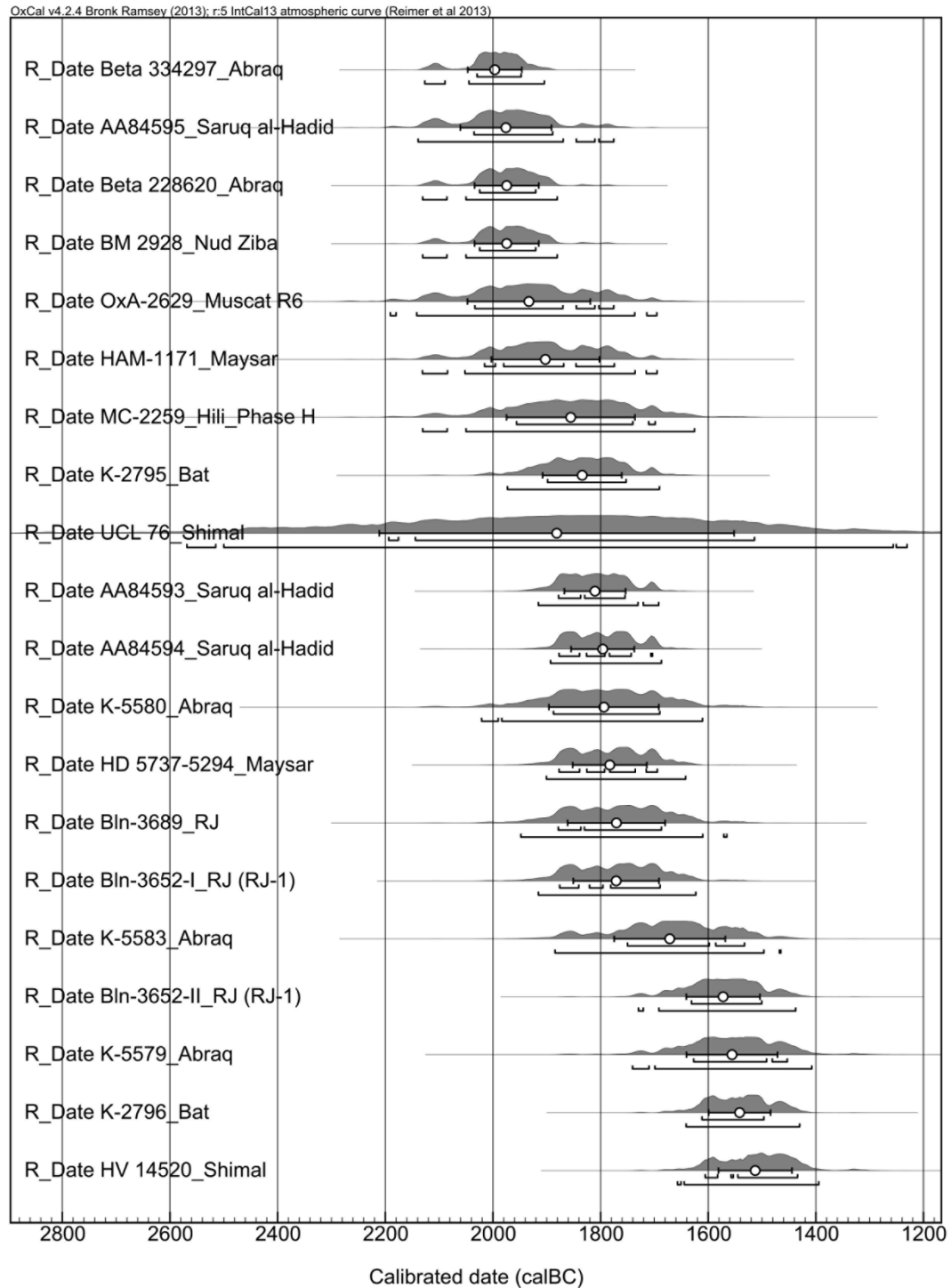


Fig. 5.2: Relevant C-14 dates for the 3rd and 2nd millennium in south-east Arabia: Dates calibrated with Oxcal 4.2 and IntCal 13 calibration curve (Bronk Ramsey 2009; Reimer *et al.* 2013)

The C-14 data from good contexts are consistently pointing to the late 3rd millennium BC as the end of the Umm an-Nar period (**Fig. 5.2**).

5.4: Continuity and change from the 3rd to 2nd millennium BC

As crucial as cultural continuity in the archaeological record may be, there are marked differences which set the Wadi Suq period apart from the preceding Umm an-Nar. The extent of these changes remains to be studied in more detail, with this chapter trying to contribute to that effort. In a recent synthesis of Arabian archaeology, Peter Magee speaks of ‘massive social changes’ (Magee 2014, 124). This is in line with a recent overview of the Early Bronze Ages in the Oman Peninsula, where Cleuziou speaks of ‘discontinuity and strong transformations’ with the appearance of the Wadi Suq ‘technocomplex’ (Cleuziou 2002, 192).²¹ However, there is now repeated evidence that this break is not absolute, but might rather represent a social and economic reorientation. It is thus highly relevant to assess those factors that might have contributed to this reorientation, and to examine what this reorientation entailed within the different realms of material culture.

When considering cultural change it is likely that individual archaeologists stress continuity vs. change on the basis of locally observed developments at their particular sites or region of interest, giving them a likely preference towards a certain model (continuity vs. collapse). This issue finds particular resonance when scholars working in different areas of south-east Arabia address the presence of continuity in the archaeological record. As suggested previously, settlement continuity is more pronounced in the northern Emirates, in the reasonably well watered alluvial plains of the Hajjar mountains (Ru’us al Jibal) (Carter 1997a, 233). Hence, this area of the northern Emirates has been pointed out repeatedly as an exception to the general process of a decline in (visible) settlements (Righetti 2015, 44). This might explain why the narratives of Potts and Magee stress continuity as they are taking a ‘northern Emirate’ perspective, specifically focussed on the site of Tell Abraq excavated under their direction (Potts 1986b; Potts 1989a; Magee 2014), while Cleuziou, who refers more to the situation as experienced from his fieldwork in Oman, stresses the breakdown of the settlement pattern and social structure of the previous Umm an-Nar period with a subsequent focus on pastoral practices (Cleuziou and Tosi 2007). Both

²¹ Interesting is the use of the word ‘technocomplex’ which goes back to David Clarke’s work and already suggests the heterogeneous nature of Wadi Suq ‘culture’, in Clarke’s words showing: “differing specific types of the same *general families of artefact-types*, shared as a widely diffused and interlinked response to common factors in environment, economy and technology.” (Clarke 1968, 188).

stances likely have validity, but should be viewed within a framework of regional trajectories within south-east Arabia.

5.4.1: Wadi Suq settlement and subsistence

Initially, the Wadi Suq was seen as a final period of sedentarization before more mobile ways of life became dominant (Cleuziou 1981, 279). However, due to the relative paucity of settlement data, there is still much information lacking on patterns of subsistence in the Wadi Suq period. As Magee recently summarized (2014: 152): “It is still difficult to understand these periods fully given the relative paucity of settlements, but it is clear that the intensification of settlement that characterized the Umm an-Nar period gave way to an archaeologically less visible exploitation of the landscape.”

5.4.2: Settlement data

The settlement data for the Wadi Suq is relatively scarce and has been summarized recently (Magee 2014, 186-189). The data will not be repeated extensively here, suffice to say that according to Magee’s recent summary, a ‘radical’ reorientation of settlement location and subsistence can be detected. However, there is reason to doubt this radical nature of settlement change, as continuity in settlement location is attested for a number of important sites that show previous Umm an-Nar occupation such as Tell Abraq, and Kalba (Carter 1997b; Carter 1997a; Magee 2014; Potts 1991). Perhaps not coincidentally, these sites can be seen to lie in the northern part of the Emirates (see **Fig 5.1**). As indicated by Magee, the occupation at these sites is characterized by a modification of existing Umm an-Nar buildings (Magee 2014, 186-187). Carter classifies these sites as ‘large permanent settlements with monumental architecture’, this monumental architecture being mainly in the form of retaining walls (Carter 1997b, 87). The same re-use of an older settlement location might apply to the oasis settlement of Hili 8, where a heavily eroded walled settlement with stone houses constructed of re-used Umm an-Nar structures was built against old ruined Umm an-Nar period buildings after a period of abandonment of uncertain length (Cleuziou 1981, 280). In general, these sites seem to attest to the re-use of building material and settlement location, though with different orientation in settlement plan. At Ra’s al-Jinz in the Ja’alan area on the east coast of Oman, a change in settlement pattern is seen and the 3rd millennium BC settlement was followed by a shift in

settlement location and architecture, mainly represented by a small settlement: Ra's al-Jinz 1, surrounded by a wall (RJ-21), but a continuation of subsistence based on marine resources and exchanges via the Persian Gulf (Cleuziou and Tosi 2000, 67).

5.4.3: Settlement scale

In his 1997 overview of the Wadi Suq period, Carter makes an important division between small scale sites, possibly seasonally occupied, and large scale sites which might have been permanent settlements (Carter 1997b). He observes that the smaller scale settlements, probably settled using rather make-shift architecture, are probably underrepresented in the archaeological record due to their lower visibility (Carter 1997b, 95). Larger sites are conspicuously absent, apart from the ones mentioned already, and Carter suggests that this cannot be a result of their being overlooked, as they are highly visible and the material culture is quite recognizable (Carter 1997b, 95).

In conclusion, this 'radical change' might rather be seen as a reorientation of settlement location and architectural traditions from the Umm an-Nar period, but can be questioned as a wholesale shift on a number of points. For one, it may be questioned how representative the settlement data we have is. A number of the excavated settlements are either very poorly preserved or partially explored. For instance, the site of Tawi Sa'id, often cited as one of the few explored Wadi Suq settlements in Oman, was very badly preserved and consisted of little more than a surface scatter of Wadi Suq material associated with badly deflated mudbrick architecture (de Cardi *et al.* 1979). In general, we still lack substantial archaeological coverage in areas that might show continuity in settlement patterns, such as the previously mentioned Batinah coastal plain of Oman. Added to this fact, older surveys might have been predominantly vehicle based and targeted more clearly visible features. Some areas might yield new discoveries with more intensive pedestrian survey and the greatly improved help of aerial and satellite imagery (Düring and Olijdam 2015; Deadman *et al.* 2015; Herrmann *et al.* 2012).

One of the most significant sites that has been underexplored for various reasons is Nud Ziba, located close to the natural springs of Khatt at the foot of the Hajjar mountains, and very likely in a subsistence zone with large potential for agricultural activity (de Cardi 1994; Kennet and Velde 1995). Limited finds from an exposed cut

suggest that the storage of agricultural goods might have been significant, with large storage jars as part of the pottery assemblage (Kennet and Velde 1995, 88: Fig.8; 89: Fig 9). A radiocarbon date suggests this phase with storage rooms and large jars to date right at the cusp of the 2nd millennium BC (2131-1881 cal BC (2 σ) see **Fig. 5.2**). Moreover, the collection of a large number of carbonized date stones is reported (Kennet and Velde 1995, 85). These finds suggest date consumption was likely linked to date palm exploitation, as in the preceding Umm an-Nar period. The likelihood of an earlier Umm an-Nar settlement at Nud Ziba is supported by a substantial lower ‘tell’ which might yield still unexplored Umm an-Nar remains that would point to possible continuity at the change of the 3rd to 2nd millennium BC (Kennet and Velde 1995, 82). Thus, Nud Ziba still promises to be a key site at which to examine how the changes in social and economic organization relate to changes in the environment. It will likely show adaption and persistence in habitation into the 2nd millennium BC, having the advantage of nearby springs to guarantee access to water withstanding the general aridification. Despite a far from complete archaeological record of settlements, more recent survey data from Oman obtained by the extensive collection of sherds in areas of wadi agriculture, which likely represent areas of almost continuous agricultural practices throughout the past, point to a general decline in settlement activity in the Wadi Suq period (al-Jahwari and Kennet 2008; al-Jahwari and Kennet 2010).

In sum, settlement evidence for the Wadi Suq period both yields evidence for decline and for the re-use of older settlement locations but with a distinctly different architectural lay-out. It remains however crucial to account for the fact that the settlement evidence is still biased towards a few excavated sites, although a growing number of surveys, some using intensive methods have the potential to tackle the bias of the incomplete geographic coverage and heavy re-use in later periods affecting archaeological preservation.

5.4.4: Pastoralism, agriculture and fishing

Due to the general lack of (excavated) settlements, we do not possess as much information on subsistence in the Wadi Suq in comparison with earlier periods (Magee 2014, 187). This led Potts to suggest two decades ago that “...we know less about the economy of the interior of the Oman Peninsula during the Wadi Suq period than during virtually any other period in the region’s past” (Potts 1990a, 256). This

lack of settlements in comparison with the preceding Umm an-Nar (2500-2000 BC) and the nature of known occupation has led to an initial picture of higher mobility in this period, intrinsically linked to pastoralism (Cleuziou 1981). Our evidence so far seems biased towards settlements with a strong coastal component, like Tell Abraq, Shimal, Kalba and Ra's al-Jinz. However, Potts warns against overly rigid distinctions between coastal and inland life-ways, as they have historically often demonstrated intriguing interwoven patterns (Potts 1993a, 166). Excavated sites such as Tell Abraq (Ajman Emirate), Ras al-Jinz (Oman), and Shimal (Ras-al-Khaimah) have revealed diverse subsistence patterns heavily bound to the local environmental conditions of the sites (Cleuziou and Tosi 2007; Magee 2014, 187; Uerpmann 2008; Vogt and Franke-Vogt 1987). At Abraq, indirect evidence for agriculture exists in the form of date stones with grinding stones suggesting the processing of cereals (Carter 1997b, 94). Sites such as Nud Ziba, located in the foothills of mountains away from direct connection to the sea, and in an area of high agricultural potential, probably relied more heavily on terrestrial resources and agricultural produce. Faunal remains from Shimal settlement (now considered mostly Late Bronze in date) suggest the presence of camel, sheep, goat, cattle and pig and thus the presence of animal husbandry (Carter 1997b, 94). However, as recently argued by Magee, the presence of at least the camel bones can likely be considered as a hunted species before their introduction as a domesticated beast of burden in the Iron Age (Magee 2014, 200, 212).

5.4.5: Evidence from isotopic studies

Recent isotopic studies using human remains from both Umm an-Nar and Wadi Suq period tombs suggest not as radical a shift as proposed on the basis of scarce settlement data (Gregoricka 2013). This argument is developed further in a recent article, where Lesley Gregoricka (2014) argues for a degree of continuity in life-ways adapting to rapid environmental change from the Umm an-Nar to Wadi Suq period on the basis of isotope studies from human remains of Umm an-Nar and Wadi Suq period tombs at Shimal (Gregoricka 2014). The isotope data suggests continuity, and thus Gregoricka argues for gradual societal changes, instead of rapid breaks between the two periods. This is very much in line with the argument above regarding settlement data and also fits the data now becoming more apparent from material cultural studies (see below on ceramics). Gregoricka (2014) suggests that the strontium signatures show the persistence of reliance on a sedentary lifestyle (i.e. the

lack of life-time mobility shown in strontium signatures) corresponding to the lack of variability in carbon isotopes between the two periods and a dominant reliance on C₃ plants. However, elevated oxygen isotopes in the sampled Wadi Suq population are interpreted as evidence of increasing aridity (Gregoricka 2014).

5.5: Cause for change

5.5.1: Magan, Dilmun and the Indus Valley

As already suggested in the introduction, the area of south-east Arabia, and perhaps the Iranian coast across the Hormuz, are part of what was designated in Mesopotamia as ‘Magan’ during the 3rd and start of the 2nd millennium BC (Cleuziou and Tosi 1994; Heimpel 1988; Potts 1986a; Potts 2003). However, the social and political integrity of this designation is far from certain (Potts 1986a; Thornton 2013). In general a decline in contact with the wider region of Iran and Indus Valley at the start of the 2nd millennium BC onwards is indicated by the relative absence of material culture from these regions in contrast to its frequency in the preceding Umm an-Nar period (Carter 2001; Méry 2000). During this period, Dilmun is seen to have become more dominant in international relationships as the main contact between Mesopotamia and the other areas in around the Gulf including south-east Arabia (Carter 2003a; 2003b; Terp Laursen 2009). Repeated evidence for ceramics from the Dilmun sphere (modern Bahrain) is found in both settlement data and the burial record, mainly in the form of imported vessels (Grave *et al.* 1996; Méry 1998).

5.5.2: Role of climatic stress: the 4.2 kyr BP event

One of the possible drivers of the different trajectory and social changes in the 2nd millennium BC in the south-east of Arabia is climatic change. On the basis of core drillings and the collection of geomorphological data from a paleo-lake at Awafi (Ras-al-Khaimah) Adrian Parker and colleagues were able to show a period of distinct desiccation in the area around 4.2 kyr BP (Parker *et al.* 2006). This period of desiccation would correspond to the change in subsistence patterns attested at the start of the 2nd millennium BC (Goudie and Parker 2011; Goudie *et al.* 2006; Parker 2008). The 4.2 kyr BP ‘event’ finds resonance across the Near East and has been suggested to form the reason for cultural change in different areas (Bar-Matthews and Ayalon 2011; Finkelstein and Langgut 2014; Langgut *et al.* 2014; Langgut 2015; Staubwasser and Weiss 2006).

Magee has recently summarized these strands of evidence, calling explanations of the social shift which focus on changes in centre-periphery relations with South Asia or Mesopotamia ‘entirely unconvincing’ (Magee 2014, 124; referring to Edens 1992). Yet also, Magee expresses his reservations regarding the likelihood of there being a clear-cut causal link between the social shift and climatic change (Magee 2014, 124). As evidence he points out that while Parker (2006) cites a total desiccation around 2200 BC, Tell Abraq and Hili demonstrate a ‘vibrant cosmopolitan economy well into the twenty-first century’ (Magee 2014, 124). Although the author is right in stressing the importance of local trajectories, rejecting the role of climate is somewhat contradictory to Magee’s otherwise more nuanced approach to social change in the Arabian Peninsula, with its particular appreciation of the role of the local geographical situation. It must be remembered that changes in society will rarely have a single cause. Reasons such as environmental stress, social stress and shifts in economical focus might have worked in tandem to create long-lasting changes (Wossink 2009; Wossink 2010; see now: Lawrence *et al.* 2016).

Altogether, Magee’s argument seems somewhat invalid for several reasons. Environmental stress does not necessarily provoke an acute response. Slightly anachronistically stated, such a response would equal an overnight switch to green energy in modern society on the basis of our worries about global warming. Far more realistic is a gradual increase in pressure on existing cultural behaviour based on a certain environmental carrying capacity, and attached to a cultural mind-set, as has for instance recently been argued for the Early Bronze Age Southern Levant (Greenberg 2002, 112-122: particularly citing Portugali’s work on cognitive maps; Portugali 1996). This would lead to increasingly imbalanced behaviour in regards to environmental stress, causing more long term changes. We might follow these changes into the 2nd millennium BC. Such local adaption to ‘shifting environmental conditions’ is otherwise an integral part of Magee’s work (Magee 2014, 124-125). A more gradual social response to acute environmental changes is also in line with the above mentioned evidence from isotope studies. Most importantly, the reason for social change in the 2nd millennium BC does not have to be a question of *either* change in the more regional configuration of trade-networks *or* environmental change. Of greater likelihood would be an intricate interplay in line with more recent historically attested periods showing shifting areas of economic and political

attention, and local adaptive strategies to environmental stress.²² This is particularly relevant as climate change has been pointed out as a factor in large scale societal changes in the surrounding region, such as the Akkadian Empire, Harappan civilization, and the developments in south-east Iran (Cullen *et al.* 2000; MacDonald 2011; Madjidzadeh and Pittman 2008). Although lacking good climatological information, aridification is thought to have played a role in societal changes in east Iran as well (Pittman 2013). Here an important process of urbanization in the Hilal Basin (Jiroft) was seemingly affected at the end of the 2nd millennium BC (Madjidzadeh and Pittman 2008; Pittman 2013). This likely had an as yet understudied effect on late Umm an-Nar society, strongly connected as seen through the lens of material culture and within relative ease of distance just across the straits of Hormuz. Such environmental change could have triggered societal change over a large geographical area working like a ‘snow-ball’ effect along long established Bronze Age connections.²³ Interestingly, Gregoricka (2014) has recently argued that the dispersal of population from previous Umm an-Nar settlement clusters might have been an active choice to counter environmental stress, mitigating developing social hierarchies and countering inter-communal violence (Gregoricka 2014). The issue of the mediation of social cohesion is a recurring debate within Bronze Age south-east Arabia and will be argued to play a role in the way ceramics evolve in the Wadi Suq period.

Working with ceramic data, it is important to consider how these environmental changes might have impacted on the way ceramics were produced and used by societies undergoing these changes. As has been suggested in chapter 3, environmental amelioration and severe aridification such as the 4.2 kyr BP event can influence ceramic production due to lesser availability of fuel (vegetation), water (clay mixing and levigation) and change in the procurement of clay and temper due to a shift in settlement patterns. With a lower water supply, decisions might be made by potters against the high use of water, thus affecting the process of levigation. Fuel

²² As Clarke already suggests: “This observation suggests that many cultural system changes cannot be considered as the consequence of a single attribute or entity transformation, or of a single environmental change; it does not rule out that this may be so but makes it a limiting case.” (Clarke 1978: 78).

²³ This change could have occurred in many intricate ways. For instance, the influence of changing Monsoon is used to explain changes in Harappan society by Macdonald (2011), but might also be looked at in terms of changing sailing conditions, possibly disrupting long established sailing routes, and seasonal timing which might have had a role across the Gulf.

procurement and firing regimes might alter with changing availability of good fuel due to environmental factors (less trees/wood) (§2.4.5). However, it is likely that changes can also be causally connected to environmental change in a more indirect way, for instance with a change in settlement pattern (abandonment from areas hit more severely by aridification) leading to new areas for the procurement of clay and temper, and thus material with different workability and firing properties. One such shift might be related to the Wadi Suq period and settlement continuation (and refocus?) in the Northern Emirates (Carter 1997a).

According to Cleuziou, the ‘apparently abrupt transformation’ in the archaeological record of the Early Bronze Age into the Wadi Suq period must be interpreted as the materialization of ‘deep transformations in social structures’ (Cleuziou 2002, 228). However, this link between material cultural change and social practices is far from clearly established for the Wadi Suq period, as will be demonstrated below.

5.5.3: Tomb architecture: single or collective and the ‘underground movement’

In contrast to the limited body of settlement evidence, the Wadi Suq period is characterised by extensive burial record in the form of collective and single burial tombs, exceeding the known settlements and thus providing a bias. The typology and distribution of tombs has recently been summarized by Righetti (2013; 2015). This thesis will not treat the full extent of typological features but describe the regional variety in tomb types visible in the archaeological record. Tombs are fairly equally distributed along the northern Gulf and Indian Ocean, along the foothills of the Hajjar mountains and the inland oasis belt (Carter 1997b, 87; Righetti 2013). Another important concentration of tombs is found more inland at Jebel Buhais, a marked mountain between the east and west coast of the Peninsula, which has provided evidence of being a repeated focal point for burial activity starting in the Neolithic and continuing well into the Iron Age (Jasim 2012; Magee 2014; Uerpmann *et al.* 2006). A large diversity of tomb types exists for the Wadi Suq period, and can be split up in two main groups, those in the form of small cist-like structures for the burial of one or two individuals, and large monumental tombs for successive collective burials. Although these structures occur together, there seems to be a pattern suggesting the larger monumental tombs cluster to the north of the Peninsula in the foothills of the Hajjar mountains, whereas small cist-like subterranean structures are found in these

cemeteries as well (such as Shimal) but dominate in the region of present day Oman (such as al-Akhdar mountains), for instance at Sāmad al-Shān (Yule 2001) (See Fig. 5.1).

The concentration of tombs in the north of the Peninsula (modern Emirates) is attributed to the possible bias of the higher amount of fieldwork in this area of south-east Arabia (Carter 1997b, 87). As mentioned before, the lack of extensive fieldwork, especially on the Batinah coast of Oman, might influence this picture substantially in terms of both settlement and tomb evidence. Recently at least two renewed surveys have started targeting different stretches of the Batinah, focussing on the hinterland of Sohar (Wadi al-Jizi), and on the area of Rustaq (Düring and Olijdam 2015; Deadman et al. 2015). Nevertheless, the evidence from the Wadi al-Jizi (and Wadi Suq) corroborates the picture of small cist tombs in these regions (Frifelt 1975; Düring and Olijdam 2015).

The present data, taken at face value, also suggest another development. Whereas Oman shows evidence for monumental tombs for successive burials in the preceding Umm an-Nar positioned close to settlements, the overall picture for the subsequent Wadi Suq period suggests a move towards smaller cist graves, with or without associated settlements (Righetti 2013). The area of the Northern Emirates does yield small cist graves, but is dominated by monumental built tombs used for multiple interments over extensive periods of time. Interestingly, Jebel Buhais poses something of an exception, as it yields both smaller cist-burials, and larger tombs with multiple chambers, but constructed subterranean as opposed to their counterparts in the northern Emirates. This might be seen as a possible ‘underground’ movement specific to this site, related to local traditions and geological conditions. The northern region shows the potential for more pronounced continuity in successive burial traditions within monumental tombs, as these practices are inherited from the Umm an-Nar period collective burials in multi-room circular monumental tombs, the most striking examples decorated with ashlar masonry.²⁴

²⁴ It will be interesting to see what kind of tombs the renewed archaeological attention for the Batinah will yield for the Wadi Suq, as a tradition of small cist-burials seems to exist to the south (al-Akhdar region) but monumental tombs are constructed to the north (Mereshid and Kalba).

The reason for this difference in continuity of tomb architecture has been sought in changing population densities. It might be that the move towards smaller cist tombs, easier to build and used for the interment of a limited number of people at any time, reflect lower population density and smaller group size, whereas collective tombs in the north relate to more stable and larger population sizes along the foothills of the northern Hajjar mountains (Carter 1997a). Nevertheless, cemeteries of cist tombs can yield substantial numbers of tombs (Wadi Suq itself, Akhdar), this aggregate process eventually yielding a total amount of burials similar to the collective tombs in the north. Perhaps the reason for a diversification in tomb architecture has to be sought in the difference of group sizes related to the construction of a single tomb at any particular time; either constructing cist tombs with a few individuals, or the labour involved with extracting large limestone blocks and erecting the monumental tombs which need a larger labour pool to work. The difference might thus lie in the ability to congregate a large number of individuals at a particular time of the year to construct monumental architecture. The same would hold true for other monumental architecture such as the construction of the enigmatic ‘towers’ so typical for Umm an-Nar architecture in the preceding period (Cable and Thornton 2013). The role of population size and ceramic production will be taken up again further below.

Despite the differences in tomb architecture introduced around the transition from Umm an-Nar to Wadi Suq period, the continuity in constructing communal tombs (although perhaps containing less individuals, yet this has to be quantified) is very relevant. If we follow Magee’s (2014: 120-121; after Cleuziou and Tosi 2007, 132) reasoning that the tombs were partly functioning to absorb possible differences in status by incorporating them into monuments for common ancestors, than what does the change in funerary culture within the Wadi Suq period mean?

5.5.4: Evolution of Wadi Suq tombs

Christian Velde has argued for a chronological development of tombs in the Wadi Suq period, based on the technique of tomb building and shape of the tombs (Velde *forthcoming*). His ideas are partly based on an earlier synthesis by Burkhard Vogt (Vogt 1985). However, the re-use of the tombs often hampers the establishment of the

kind of patterns within material culture that would be required to clearly corroborate this chronological development, and has for instance prevented Carter from being too rigid in terms of chronological classification (Carter 1997a). For now I follow an interpretation of the architectural sequence which suggests a preliminary development from Umm an-Nar style collective, round, and above ground tombs with internal walls, to round tombs with a typical 2nd millennium BC wall technique of rubble filled cores, such as attested at Idhn and Qarn al-Harf 6 (Vogt 1998, Kennet *forthcoming*). A later development would see the construction of oval tombs with internal walls dividing the tomb into chambers (traditionally called the ‘Ghalilah’ type). Further change would see the construction of highly elongated tombs with corbeled roofing (‘Shimal tomb’), which no longer have any internal dividing walls. Another development is attested in subterranean cist tombs in the late Umm an-Nar period (e.g. Hili-N) (Al Tikriti and Méry 2000). These could be seen as ancestral to single – or double – cist tombs in the Wadi Suq period. However, there are important regional differences, and multiple factors can play a role, such as the local geography and suitability of building material.

5.5.5: Tomb development at Shimal

Although Carter offered his reservations as to a clear-cut chronological development of tombs (Carter 1997a), Christian Velde has proposed a ceramic seriation related to tomb development (Velde *forthcoming*). Here, Velde uses painted motifs to show that there is a development through time in decoration, with motifs being more complex at the start and ending with wavy lines, horizontal lines or no decoration at all (Velde Shimal and Dhayah). This pattern of simplification can be seen to be quite common in ceramic development. It tentatively shows that the ‘oval’ tombs (‘Ghalilah’ type) are predecessors to the ‘Shimal’ type (elongated tomb), thought to be latest in the sequence. Small subterranean cist burials seem to show predominant evidence of earlier Wadi Suq ceramics (Velde *forthcoming*).

5.5.6: Transitional Umm an-Nar to Wadi Suq tombs

The Wadi Suq actually shows a large variety of tomb structures, most recently summarized by Righetti (2013). Despite the large variety, which might show geographical differences along chronological lines, a development with Umm an-Nar ancestry might be suggested. Umm an-Nar tombs are usually circular in design, with

an outer facing of worked stones (sometimes called sugar-lump due to their smoothed rectangular shape), and often show multiple internal divisions in the form of internal walls. The entrance is often elevated from the floor and well carved, and in some cases anthropomorphic figures, animal figures or less clearly identifiable objects are carved above the door (Bortolini 2013; Cleuziou 2003; Jasim 2003, 94: Fig. 28). Bortolini has recently suggested that the evolution of Umm an-Nar tombs might be studied with phylogenetic methods, though his results as published in a preliminary study are not straightforward (Bortolini 2013). Moreover, this study involves the 3rd millennium BC and shows the evolution of Umm an-Nar tombs from Hafit cairns, but does not discuss the following developments into the Wadi Suq period.

A few tombs show structural characteristics usually associated with Umm an-Nar tombs but have a clear material cultural association with the Wadi Suq period. A round tomb with internal walls was excavated at Idhn, is likely to be a transitional form of architecture, although the material is unfortunately not fully published as yet (Vogt 1998). Another tomb at Qarn Bint Sa'ud is rectangular in shape, but shows the same internal division into multiple rooms by the construction of two internal walls added to the outer wall, with a small passage to connect the rooms (Carter 1997a, 36). Recently, two tomb types attested at Qarn al-Harf have been excavated that show similar transitional features (Kennet *forthcoming*). Qarn al-Harf 6 is an above ground semi-circular tomb, 10x9.4 m with two internal walls connected to the outer ring wall on the south side, and allowing a small passage in front of the elevated entrance on the north side, effectively dividing the tomb into three compartments. Four closely aligned tombs on a ridge (QaH1) are rectangular in plan and differ in size, but show the same arrangement of two walls abutting the outer wall on one side, and leaving space in front of the entrance. As such, the architectural plans of these rectangular tombs are very close to the plan of the rectangular tomb at Qarn Bint-Sa'ud.

5.5.7: Tomb development at Qarn al-Harf

The preliminary chronological scheme based on the archaic architectural features would suggest an early position for the tombs of Qarn al-Harf 1 and Qarn al-Harf 6, both showing earlier Umm an-Nar characteristics, followed by Qarn al-Harf 5 (Ghalilah with double internal wall), and subsequently by Qarn al-Harf 2 (elongated 'Shimal' type) and Qarn al-Harf 2a (subterranean 'Shimal'). Following this architectural argument, the cladistics analysis of the ceramics in chapter 6 can offer an

independent evaluation of the plausibility of this process of descent with modification, which might subsequently be interpreted in chronological terms. This will gain further ground when the patterns are placed in their regional perspective. We can use phylogenetic methods to test a) whether an evolution in ceramics can be observed which would also fit the assumptions on tomb development and b) place the developments in ceramic techniques into a social-cultural and environmental framework, where the choices of potters in making ceramics are placed within local developments.

5.5.8: Challenge: re-use of tombs

A considerable challenge to establishing a chronological sequence of tombs is the repeated re-use and disturbance of collective tombs (Carter 1997b, 88). This was a reason for Carter to remain sceptical about a clear-cut chronological development in tomb architecture for the Wadi Suq. Added to this is the diversity in unique types of tombs displayed at for instance Jebel Buhais (Jasim 2012). However, detailed study of the tombs at Shimal and their related assemblages do hint at a possible development, obscured by re-use of the tombs, but providing a glimpse of the possible chronological development (Velde *forthcoming*). The recent evidence at Qarn-el-Harf has the opportunity to add to this proposed chronology, as tombs with different architectural designs were excavated and provided extensive funerary remains. A simplified image would suggest that Wadi Suq tombs, at least the subterranean branch, developed from circular structures with internal divisions (Qarn al-Harf tomb 6 and Idhn) to oval tombs with an internal wall (*Ghalilah type*) and later into elongated tombs without internal divisions, but with benches (*Shimal type*). A late type yields a subterranean compartment covered with large stone plates (QAH2A, Dhayah, Sharm, Bithnah). Within this chronological scheme the earliest tombs can be compared to the ancestral shape of round tombs with internal divisions, as known from the preceding Umm an-Nar period. One such transitional tomb has now been fully excavated at Qarn al-Harf (QaH6). As already suggested, another circular tomb found at Idhn (IN-5) shows Umm an-Nar transitional features, including the round shape, internal subdivisions and slab pavement (Vogt 1998, 277; Carter 1997a, 30). The tomb measures 9 meters in diameter and features two internal walls resulting in three subdivisions, thus very similar in design to tomb QaH 6.

5.6: Changes in crafts

5.6.1: Stone vessels

Soft stone (steatite/soapstone) vessels form an important group of artefacts associated with settlement sites, and, to a greater extent, funerary contexts. These show a characteristic development rooted in Umm an-Nar ancestry, alongside the introduction marked changes in decorative style (David 1996). At the start of the Wadi Suq, David witnesses an expansion in the type of soft-stone used, both in colour and texture (David 1996, 38). As David attests “the shapes of the vessels are inherited from the “Umm an-Nar” style but evolve with a lot of variants.” (David 1996, 38). The shapes show general continuity, but diversification in morphology. The decoration becomes prolific and is executed all over the vessel. Motifs now entail horizontal lines, chevrons, and rows of dotted circles (though often single dotted). Rarer are naturalistic motifs such as trees and hatched designs (David 1996, 39). Significantly, the technical quality of the soft stone used is lower than its Umm an-Nar predecessor. Thus, a diversification in material, designs and decoration can be attested together with a lower standard of fabrication. This is very reminiscent of the development of ceramic production (see below), and both can be seen as changes in the organization of production likely related to scales of specialisation, as remarked by David (1996: 42).

5.6.2: Metalwork

Copper alloy metal objects form an important part of the Wadi Suq craft traditions. These found in the form of containers, such as beakers and handled vats; and tools, including so-called razors; and weapons, these ubiquitous in the form of daggers and socketed spearheads (Velde 2003; Magee 2014). Some of the metal beakers bear resemblance to ceramic vessels and might have shared their function, with metal examples being perhaps more prestigious items. Perhaps the most conspicuous items are animal pendants produced in precious metals such as gold, silver, and electrum.

5.7: Pendants: a cladistics case study and excursus into Bronze Age connections

Of particular interest are pendants made from gold (electrum) or silver, worked in the shape of animals such as lions, bulls and caprids (often double headed), and which are found in a number of Wadi Suq graves (al-Tikriti 1989; Carter 1997a, 99; Cleuziou

1979; Cleuziou 1981; Jasim 2012; Velde 2003, 111; Weeks *forthcoming*). Most well-known are caprids, positioned antithetically, and sharing a single body. These pendants, often with small ringlets on the back to be suspended on a necklace or sown on clothing, are among the most outstanding prestige objects in the Wadi Suq. They are often found in secondary deposits (offering deposits) or ‘hoards’ of precious goods interred in collective tombs (such as Shimal tomb 99; Qarn al-Harf tom 6), or in contexts associated with the subsidiary graves (such as Dhayah) (Carter 1997a, 99; Kästner 1991, 241; 242: Fig.6; Velde *forthcoming*, 99). This prohibits more detailed analysis of their chronological development as so far they have been grouped together. However, early variants from the late Umm an-Nar tomb at Tell Abraq suggest they have their ancestry in the Umm an-Nar period (Potts 2003, 314; Velde 2003, 111). Moreover, the excavation at Qarn al-Harf adds three pendants, two of which might show earlier features. A notable difference seems to be the technique of (single mould) casting with fine design employed for some of the pendants, whilst the later examples seem to be cast with subsequent extensive working such as adding features, cutting and incising decoration.²⁵ Another difference might be in single headed animals versus double headed animals. Significantly thus, we may expect a chronological development related mainly to technical skill in casting, which has been obscured because the pendants have largely been deposited in caches associated with collective tombs likely representing centuries of activity. It is therefore likely that such pendants, made at distinctly different points in time were interred together, and it seems these objects functioned as possible *heirlooms* before being interred with the ancestors.

5.7.1 Outgroup

As an outgroup two identical bulls, likely part of a single pendant from a hoard in Quetta (Pakistan) were chosen (Jarrige and Hassan 1989) These pendants found on an important transit point to the Indus Valley, are associated with the so-called ‘Bactria-Margiana’ or Oxus civilization and could represent a distantly related metallurgic tradition with known cultural contact during the late 3rd to 2nd millennium BC (Jarrige and Hassan 1989; Kenoyer 2003, 383-384). A very closely related identical double pendant (connected with a metal bar) has been found at Gonur Tepe, Turkmenistan,

²⁵ A detailed study of these pendants from Qarn al-Harf has been conducted by Lloyd Weeks and will be part of a forthcoming publication (Weeks *forthcoming*).

on a necklace connected to a burial of an adult male (Sarianidi 2007, 150; 151: Fig. 29). This necklace connects the tradition of these pendants and fine metallurgic casting with the Bactrian region. The latter has been inlaid with semi-precious stones, paralleled in a soft-stone lion (Ligabue and Salvatori 1988), which seems a local tradition (and perhaps connected with Jiroft style inlaid soft stone). The link between south-east Arabia and the region of the Bactria-Margiana Archaeological Complex (BMAC) is well established through rare imported artefacts found both in Gonur Tepe (Potts 2008) and imported goods in the late Umm an-Nar tomb at Abraq, such as ivory combs with engraved tulips, flowers which are not indigenous to south-east Arabia, but form a better known motif forming part of the BMAC (Potts 1993b, 315: Fig. 83; Potts 2003).

5.7.2: Ingroup

Sixteen pendants were used for further analysis (see **appendix 4** taxa list). Unfortunately, two reported silver pendants from a late Wadi Suq tomb at Shimal (Shimal 600) remain unpublished (Carter 1997a, 99; Vogt 1998, 279). They are reported to be made with the *repoussé* technique, thus in line with the pendants we know from Wadi Suq contexts (Vogt 1998, 279). These pendants could prove essential in the future examining the value of the cladistics test in terms of chronology. When included, these would be expected to appear among the later branches, unless they should prove to be much earlier heirlooms. The taxa included here derive from multiple locations, dating either to the end of the 3rd millennium BC (late Umm an-Nar) or Wadi Suq (2nd millennium BC). They consist of pendants from Tell Abraq (2), Hamala in Bahrain (1), Qattarah (5), Qarn al-Harf (3), Jebel Buhais (1), Shimal (1), Dhayah (2) and Bidya (1) (**appendix 4**).

5.7.3: Characters

Nineteen characters have been devised on the basis of the technical details provided in the text, figures and photographs referring to the pendants. Unfortunately much information is lacking, as drawings and photographs of the pendants often lack detail. Moreover, some measurements had to be interpreted (as stated). Yet overall, the characters coded seemed sufficient to allow for a cladistics analysis. It would be advisable to inspect the pendants, where possible, in more detail to find out more about the techniques used in crafting them.

5.7.4: Results

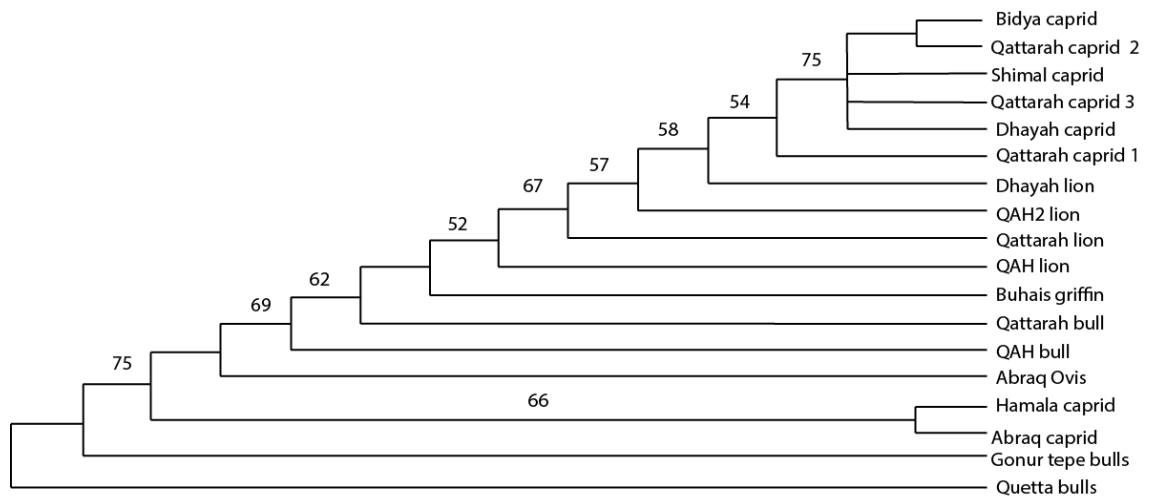
In total, 18 taxa are represented in the tree, with 19 characters, 17 of which proved parsimony informative. The cladistic analysis, using PAUP 4* and a branch and bound search yielded 96 trees with a length of 57 (Swafford 1998).

# Trees	96
Tree length	57
CI	0.6140
CI excl. uninform. Char	0.6000
HI	0.3860
HI excl. uninform. Char	0.4000
RI	0.7528
Rescaled CI	0.4624

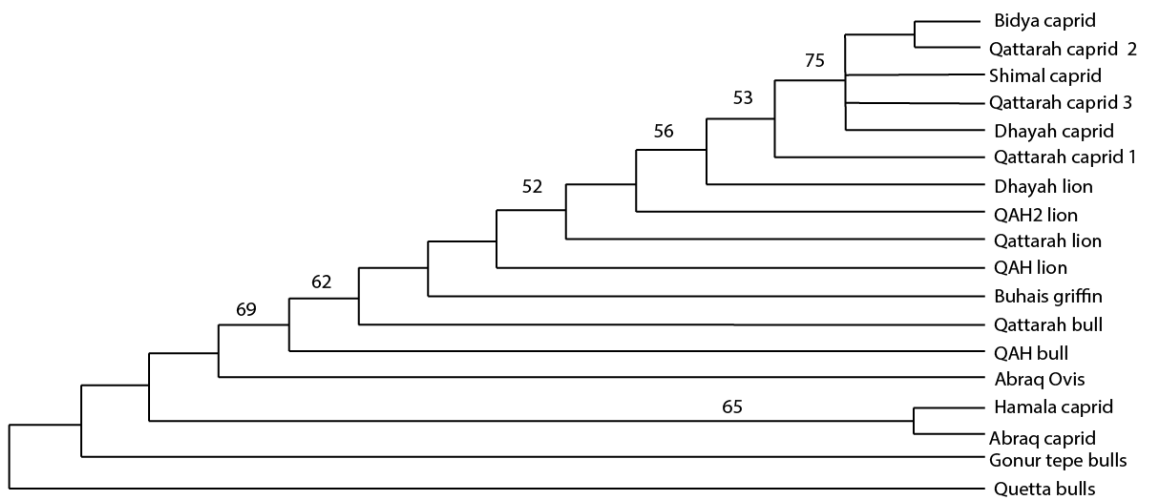
Table 5.2 Results of the Cladistic analysis of Wadi Suq pendants.

A majority consensus tree constructed of these 96 trees is shown in **Fig. 5.3**, showing clades that are present in 50% or more of the trees. Another tree, constructed as a radial phylogram is also shown using Dendroscope software (Huson 2012).

The consensus tree (**Fig 5.3**) shows a highly resolved branching pattern and seems to suggest the Quetta bulls (outgroup) and the Gonur Tepe bulls form a clade to the exclusion of the other pendants (**A**), suggesting their relatedness. Indeed, on the basis of the photographic material, they could even come from the same mould and seem highly similar in details of casting and the outstanding horns. Another early branch consists of a clade with the Hamala caprid (early Dilmun) and the Abraqa antithetic caprid (**B**). The latter was found in the late Umm an-Nar tomb and is seen as an ancestor to later Wadi Suq pendants. The Abraqa ovis, cast in a single mould and rendered detail by incisions forms another clade (**C**), branching off early and this is consistent with its late 3rd millennium BC date. Moreover, the type of sheep indicated is related by the excavator to a ‘subspecies of urial’ widely attested in Iran and the Iranian borderlands (Potts 2003, 314). We will go into the geographical significance of this later. The small silver bull from Qarn al-Harf, and the Qattarah bull (perhaps identical), branch off next (**D**). These have both likely been cast in a single mould, are small in size (L 4.7 cm; W. 3.6 cm; T: 0.6 cm for the QAH bull) and yield similar incised lines and outstanding horns. The Buhais ‘griffin’ branches off next (**E**).



Majority consensus tree (50%) with bootstraps nreps=1000



Majority consensus tree (50%) with bootstraps nreps=10.000

Fig. 5.3: Consensus tree (Majority Rule) with bootstrap results (10.000) repetition. The trees are generated by Dendroscope (Huson 2012). The length of the tree is 59. The RI is 0.73.

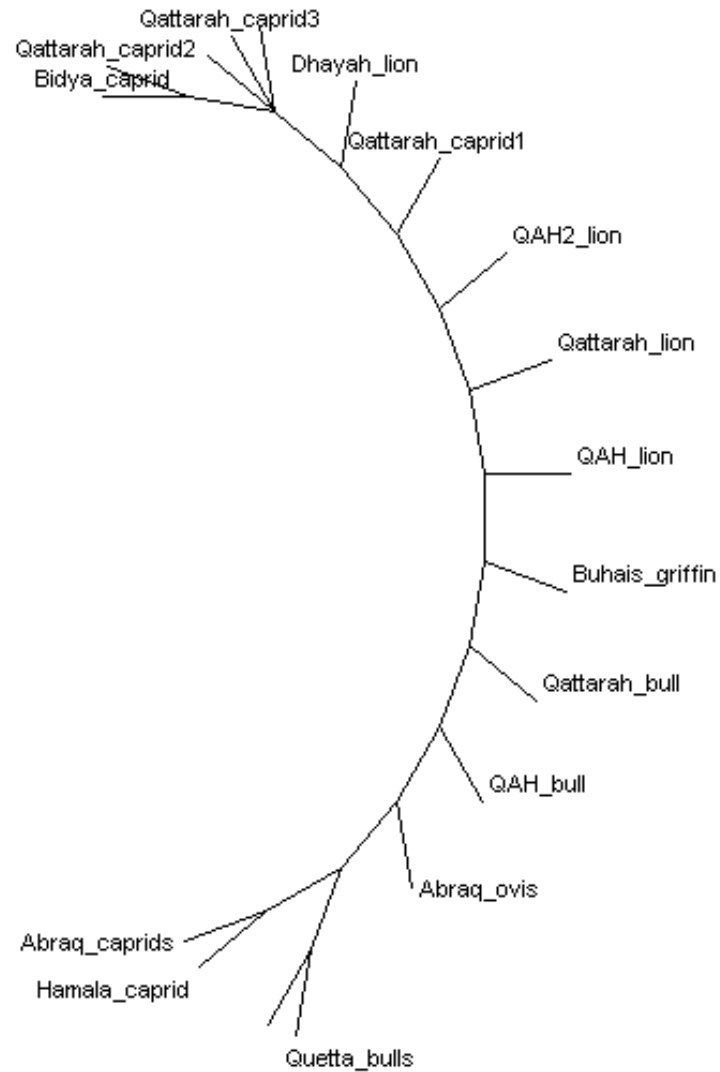


Fig. 5.4: Majority rule consensus tree drawn as a radial phylogram (phylogenetic network), clearly showing the branching pattern and clustering of the outgroup and Umm an-Nar pendants on one side, and the Wadi Suq pendants, especially the caprids, on the other end. Tree generated in Dendroscope (Huson 2012).

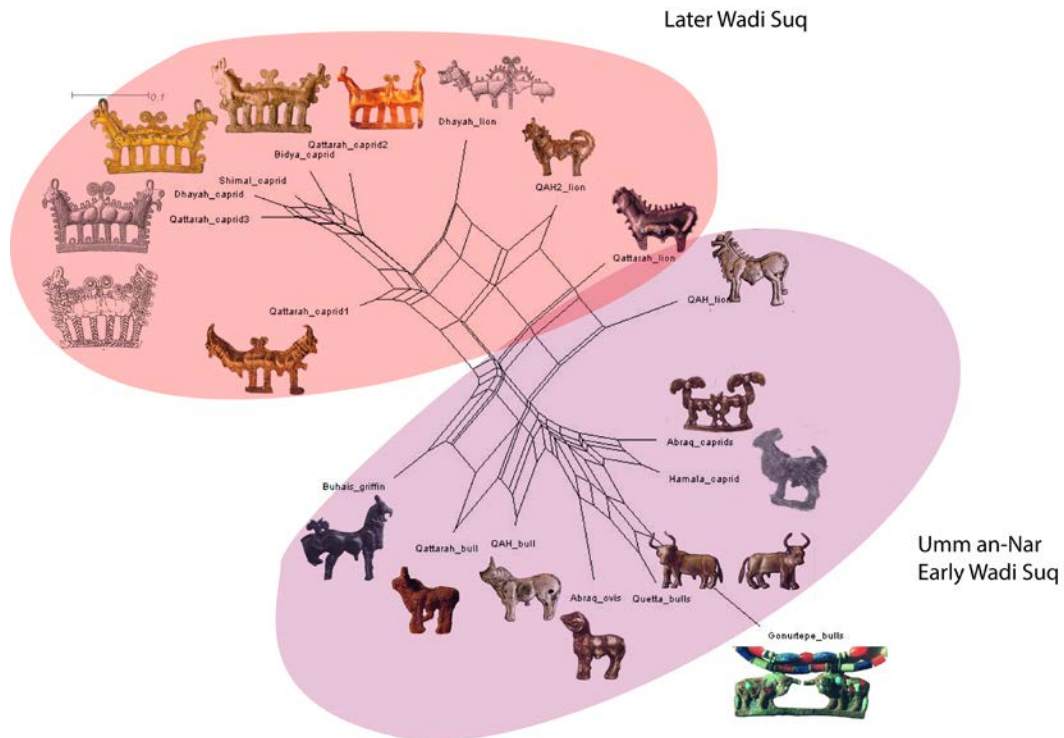


Fig. 5.5: A network showing the UNAR pendants close to the outgroup (Gonur Tepe) in the lower right corner, and the WS pendants, assumed to be later in the sequence, clustering in the upper left corner (tree generated in NeighborNet).

This would be consistent with the fineness displayed of the features, likely cast in a single mould. It might be suggested that this pendant is relatively early, and connected to a tradition of craftsmanship displayed in the bulls and lion of Qarn al-Harf. This lion is the next branch (**F**). It too features delicately cast features and incised lines. Moreover, as with the griffin, the iconography of these pendants seems highly developed, and would imply a longer standing tradition in iconography and high skill in creating the moulds. As will be argued below, we may question where these pendants would have been made. Certainly, there are no equivalents in local south-east Arabian iconography on any preserved medium. However, such iconography on cloth and textile (carpets) cannot be disregarded, and might have been crucial in the transfer of motifs during the Bronze Age — as it even today in the region, especially in traditional carpets (Tehrani 2011). Following are pendants which display both evidence of being cast, but with considerable hammering and *repoussé* to adding features to the pendants. These consist of lions (single headed and double headed) and caprids (double headed) (**G**). A caprid pendant from the tomb at Qattarah (Qattarah 1) might be suggested to show earlier features (**H**). A particularly strong clade consists of caprids from Bidya, Qattarah, Dhayah and Shimal (**I**).

The consensus tree drawn as a radial phylogram and phylogenetic network (**Fig. 5.4-5**) show particular clusters of the outgroups of bulls from the Iranian borderlands (Quetta) and Turkmenistan (Gonur Tepe) together with the late Umm an-Nar pendants from the Tell Abraq tomb on one side of the phylogram, and another cluster with the clearly Wadi Suq related caprids on the other extreme. These phylograms shows the likely chronological pattern in descent with modification backed up by the contexts mainly of the late Umm an-Nar tomb of Tell Abraq (Potts 2000a; 2000b), and later Wadi Suq tombs on the other hand. Even more interestingly, this development might probably relate to geographical factors as well. As such we might argue for two modes of transmission, the first being based on imported objects produced by a highly skilled craftsman versed in casting small objects in single moulds. Visible features such as the type of animal, and design features, might have been copied locally. Another tradition might be seen as genuinely local, employing casting or hammering together with annealing and adding decorative features with a sharp tool. The question would be where the transition between these two ways of producing the pendants lies, and if craftsmen skilled in casting these objects in single moulds were working locally in south-east Arabia.

Bootstrap (10,000 repetitions) shows relatively good support for number of clades (**Fig. 5.3**) (see §3.9.7 on methodology). Although a number of clades show a support under 70% which is deemed a reasonable threshold for confidence in the accuracy of the phylogenetic analysis (Hillis and Bull 1993; Tehrani and Collard 2002, 450), no real consensus exists and bootstrapping must be considered as a heuristic tool, while critical commentators have noted the lack of control on the quality of the randomly generated trees by bootstrapping (Tehrani and Collard 2002; Makarencov *et al.* 2010). Bootstrapping is used in these case-studies as a tool for relative support (§3.9.7), and it suggests the pattern shown in this phylogram still has significant value with bootstrapping showing support for multiple branches from 52-75%. It is particularly useful that the clade representing the double caprids, with examples from Bidya, Qattara, Dhayah and Shimal, shows a robustness over 75% which is deemed to be particularly strong. This is significant because this suggests this clade clearly represents the branching of the (later) Wadi Suq metallurgic tradition of making animal pendants.

5.7.5: Individual characters and homology measured by the RI

We can examine the individual character traits to see which ones are particularly consistent with the suggested evolutionary development of the phylogenetic reconstruction, and show high consistency in terms of homologous descent with modification from a common ancestor. As these concepts (CI, RI, parsimony steps) were explained in detail in Chapter 3, I will provide here only a short reminder of their significance in terms of data interpretation. The CI and especially the RI are most important as it shows the way the character fits the branching pattern and supports a pattern of shared derived character state from a common ancestor. Parsimony steps are included to show the amount of ‘steps’ or changes in character states are needed to explain the branching pattern. The fewer steps are needed, the better the character fits a branching pattern.

A number of characteristics which are particularly relevant for the reconstructed branching pattern can be briefly discussed. These seem to be the size (Char 1), Type of animal (Char 3). Character 4, the technique used is very relevant to the branching pattern and fully homologous (RI of 1). This is particularly interesting as it might be the one of the main contributors to the evolution of these pendants. Recall that the change from casting in a single mould to the hammering and casting with *repoussé* should be seen as essential to the evolution of these pendants. The number of animals on the pendant seems quite relevant as well, with a RI of 0.71. However, an attestation of double caprids is attested from late Umm an-Nar Abraq, and thus shows this character to be present early on. However, it goes on to dominate in the later branches of the tree. The heads of the animals facing forward (*en face*) or sideways (*en profil*) are relevant as well (RI of 1). The head shown *en face* is an ancestral trait shown in the outgroup and the Abraq ovis pendant, and Gonur Tepe bulls. Importantly, this might be a consequence of the technique used, as the *en face* heads of animals would be partly connected to casting them in a mould. The way the legs are rendered (Char 1) is parsimony informing with a RI of 0.86. There seems a development from double separated legs (state 1), to single cast fore and hind legs separated by a line (state 2) to six separate legs. It is connected with double animal pendants, where the double caprids share the last hind leg (thus individually 1 leg short).

Char.	Short Description	# char. state	CI	RI	Parsimony steps
1	Size	2	0.5	0.80	2
2	material	3	0.5	0.33	4
3	Type of animal	5	0.67	0.67	6
4	General technique	2	1	1	1
5	Amount of animals in pendant	3	0.5	0.71	4
6	Attachment	2	1	0	1
7	Head facing	2	1	1	1
8	Legs	3	0.67	0.86	3
9	Accentuated line back	2	0.5	0.83	2
10	Spiral	4	0.67	0.5	6
11	Eyes	5	0.8	0.83	5
12	Ears	4	0.43	0.5	7
13	Teeth	3	0.67	0	3
14	Horizontal bar attached to legs	2	0.33	0.71	3
15	Loops attached	2	0.5	0	2
16	Decoration	3	0.67	0.88	3
17	Serrated sides	2	0.25	0.5	4
18	Male sex indicated	2	1	1	1
19	Infilled with semi-precious stones	2	1	0	1

Table 5.3: showing the Consistency index, Retention index and number of parsimony steps for each character used in the phylogenetic analysis.

Character 9, showing the presence of an incised line accentuating the back is parsimony informative (RI of 0.83). It seems a derived character first associated with pendants such as the bull from Qarn al-Harf. The presence of spirals seems relatively informative (RI of 0.5). It is a derived character associated mostly with the double caprids known from Wadi Suq graves. According to the phylogenetic reconstruction, an early occurrence is on the pendant from Jebel Buhais. Interestingly the spirals are here placed underneath the tail, thus not yet functioning as a tail itself (as in later cases). This might be relevant in showing the transition in use of such spirals to indicate tails. The technique of rendering the eyes (character 11) seems quite informative, with a RI of 0.83. It seems to suggest a relatively clear evolutionary development. The ancestral trait is suggested to be that it is cast with the figurine, being incised in the mould. Derived states are a punctured dot (in case of the Abraha ovis), another early feature shows the eyes not to be indicated. Later derived characters seem to be a full circle or a circle with a central dot punctured. The last trait seems to be the most recent, associated with lions and caprids showing the hammering technique. The attachment of a horizontal bar (character 14) to the feet is a derived character not present in the Quetta bull outgroup, but already associated with the bulls from Gonur Tepe. It is associated with several clades, thus showing homoplasy, perhaps due to character reversal, or horizontal transmission of this feature. However, its high RI (0.71) suggests it supports the branching pattern quite well. The technique of adding decoration seems to show considerable support for the branching pattern and suggest an evolutionary development associated with the later Wadi Suq examples. A number of pendants have a protrusion on the stomach, which could be interpreted as indicating the male sex of the animal (character 18). This trait is ancestral too and as such present in the outgroup. The absence of this protrusion seems a novel trait only associated with the clade of double headed caprids. If this protrusion is indeed indicating male sex, it is interesting in the fact that it might be shown on animals which biologically would not have this feature (from bull to griffin and lion). It might be suggested to be a rudimentary feature copied by craftsmen without realising the original significance.

The type of material seems to be fairly independent of the branching pattern, showing considerable homoplasy. This means the type of material used (gold, silver, electrum) is fairly independent of the production process and technical decisions

made, and changes multiple times within the branching pattern. It might thus be suggested that specific type of material, either gold/electrum or silver in most cases, has no direct influence on the evolution of the pendants. This could be because both metals would have quite similar properties in terms of working (casting) and hammering. However, more detailed information on the material could give possible information on the origin of the gold and silver used, and more tentatively be linked to places of making the pendants. The type of material might of course have been relevant from a cultural perspective. For instance in terms of gender division in use or other implications based in its perceived value and meaning.

5.7.6: Discussion on cladistic analysis of the pendants

These pendants likely played a role in display, being worn on a necklace or sown on clothing. They might have been particularly valued as finely crafted exotic objects, playing an important role in gift exchange and relations of power (Helms 1988). Depositing them with the deceased or in connection with tombs seem to have made them into inalienable possessions (which could no longer be exchanged) associated with the dead, establishing strong links between groups or individuals and the ancestors thus perhaps playing an important role in what Mills (2004: 238) refers to as the ‘establishment and defeat of hierarchy’.

On the basis of the cladistics analysis, a distinction might be seen in finely cast pendants, often small of size, showing signs of being cast in a single mould, with incised lines accentuating features. These pendants are consistently shown as branching off earlier. It might thus be suggested that these pendants are earlier in the sequence (although their context can be later). Moreover the technical skill of these pendants, and the iconography of bulls, lions and griffins has no parallels in south-east Arabia at the time, and might perhaps be sought the neighbouring region, with Iran and the Iranian borderlands as particularly strong candidates showing a long standing tradition of casting small animals, and the creation of mixed animals (Sarianidi 2007; Wengrow 2013). This would be in line with evidence from the Umm an-Nar period, but the presence of such pendants in the (early) Wadi Suq context would either suggest the continuation of such contacts, or perhaps the fact that these pendants were being exchanged and safeguarded for extensive periods after being fabricated and before being deposited in tombs.

The results of phylogenetic analysis support a valid question: was single mould casting, which requires considerable skill in the form of cutting or preparing the mould, and experience with casting metal, transferred via south-eastern Iran to south-east Arabia at the end of the 3rd millennium BC? (See **Fig. 5.6**). Until similar pendants are found in areas such as south-east Iran, this matter remains unresolved. Whatever the outcome of future studies, it might be suggested that this technique was not transferred into the later 2nd millennium BC, or at least not on a wide scale.

This would explain why the pendants which form later clades in the cladistics analysis, and are composed of the ‘typical’ antithetic caprids and rarer lion like pendants, are made using different techniques, such as hammering, and punctured designs. It is also significant that these two categories of animals, lions and double caprids, survive into the later 2nd millennium BC. It might be suggested that they have particular iconographic significance. Unfortunately the lack of clear association between pendants and single individuals prohibits us from saying something about issues such as gender or age connected to the use of these pendants. Moreover, a very interesting local feature seems to arise, in the addition of antithetic spirals as tails or decoration around the feet of caprid pendants. This might be suggested to be a local hybrid development incorporating the spiral motif which features on other metal artefacts such as beads (attested at Qarn al-Harf) and pins. The latter are well known from Harappan contexts as well (Miller 2013). These might be suggested to be vestigial features of the highly interconnected Early Bronze Age world of the 3rd millennium BC, having a distinct tail end in the Wadi Suq.

What is most interesting from the perspective of this thesis is that the pendants show a similar development to that attested in ceramics (see below) with an initial phase that witnesses some sharing of styles at an extra-regional level, followed by growing regionalization within south-east Arabia and an increasing focus on local craft production (see **Fig. 5.6-7**). However, this does not mean that craftspeople were completely isolated from further 2nd millennium BC Gulf connections. The preliminary study of these pendants shows the potential of phylogenetic analyses as an aid to establishing chronological patterns on the basis of the support of descent with modification for a group of artefacts. Additionally it leads to new questions and possibilities of constructing narratives of connections between regions, both in terms of exchange of objects and of craft traditions (i.e. preferences, knowledge and

techniques). Cladistics plays a similar role in the study of Wadi Suq ceramics in this chapter.



Fig. 5.6: Map showing the bull pendant in Gonur Tepe (modern Turkmenistan) and Quetta, and a caprid figurine from Hamala (Bahrain) (basemap courtesy of Google Earth; see appendix 4 for pendant references).

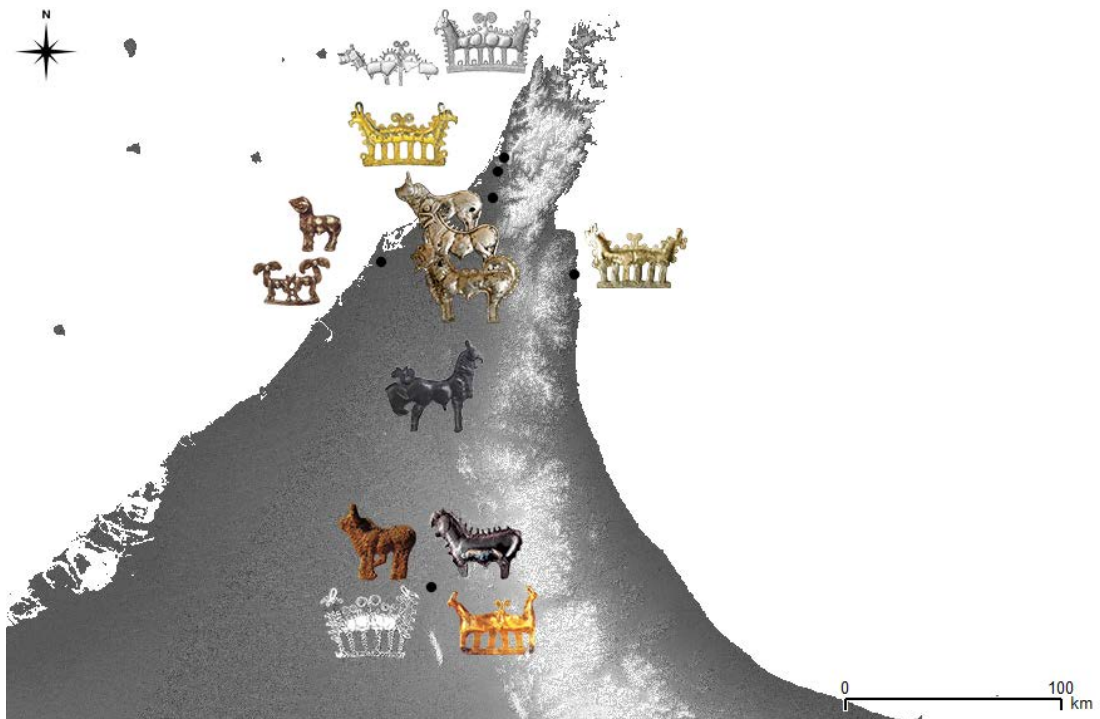


Fig. 5.7: The animal pendants are found in tombs in the northern Emirates, with the earliest examples from Tell Abraq, and Wadi Suq pendants found from Dhayah in the north to Qattarah in the south (Basemap 90 DEM courtesy of NASA; see appendix 4 for pendant references).

5.8: Ceramic continuity and change and the evolution of Wadi Suq ceramics

5.8.1: Traditional views on ceramic change from the Umm an-Nar to Wadi Suq

The conventional view is summarized in the following statements:

“At the beginning of the second millennium BC, a new set of pottery appears in the Oman peninsula, reflecting a new society...” (Righetti and Cleuziou 2010, 283).

“One of the most immediately visible changes for archaeologists is the appearance of completely new types of pottery, stone vessels, and metal objects. The shapes and decorative patterns of the pottery vessels are entirely fresh ...” (Cleuziou and Tosi 2007, 266)

As seen in the above quotes, traditionally, a clear break between Umm an-Nar and Wadi Suq ceramics has been argued. This is one of the main assumptions which will be questioned and tested by cladistic analysis. For the evolutionary analysis of Wadi Suq ceramics, it is crucial to look at the evidence for both continuity and change between ceramic practices in the Umm an-Nar and Wadi Suq. In general, only rarely can an absolute break in material cultural practices be demonstrated, and it is more likely that a break seen in the archaeological record is partly due to lack of information, and due to the archaeologist’s tendency to define a succession of archaeological periods demarcated by clear breaks, especially at the start of archaeological enquiries into less explored regions (see Campbell and Fletcher 2010: on the Halaf-Ubaid transition).

In their article summarizing the ceramic evidence from Wadi Suq occupation layers at Hili-8, Righetti and Cleuziou begin by stating as a fact that the set of pottery is new (Righetti and Cleuziou 2010, 283). Similarly but briefly, Magee (2014: 186) also stresses the completely different nature of the forms and decoration of Wadi Suq ceramics compared to Umm an-Nar vessels. Moreover, using Méry’s earlier work, Magee stresses the use of new clay sources (Magee 2014, 186; referring to Méry 1991a). He also stresses the diversification of the ceramic repertoire in comparison with the limited extent of vessel types in the Umm an-Nar, and the diversification in use-specific types such as ‘tall beakers’, spouted jars and storage jars. However, he does not take the chance to discuss the implications of these changes in types.

5.8.2: A *longue durée* perspective on ceramic change in Bronze Age south-eastern Arabia

Before we go into detail on the transition in ceramic practices from the 3rd to the 2nd millennium BC (The Umm an-Nar-Wadi Suq transition) it is good to take a more long-term perspective on the use and fabrication of pottery in south-east Arabia, as this development shows a marked local trajectory, linked to other regions in the wider Near East but with a distinct local adoption and adaptation of ceramic techniques.

Cultural contact and the extent of technical ‘current’

An interesting article by Daniel Potts (2005) takes an evolutionary perspective when looking at south-east Arabia’s local ceramic industry from the 5th to 3rd millennia. He remarks that the first ceramic contact between Mesopotamia and the Oman Peninsula was from an evolutionary perspective ‘unproductive’ (Potts 2005, 71). With this ‘unproductiveness’ he seems to imply that the presence of imported pottery did not instigate a local ceramic tradition. However, Potts does not fully work out this evolutionary stance. Moreover, recent insights by other archaeologists bring nuances to this picture. This framework can be taken as a starting point for this short synopsis using ideas already set out in chapter 2 on transmission and technical agency (§2.5). The limited nature of a locally fabricated Ubaid related tradition (at least in imitation) might be explained because the agency of the potter was not recognized in the transmitted artefact by the local recipient, meaning that a person receiving an imported ceramic vessel in south-east Arabia did not recognize the technical action, what we label the ‘technical agency’, that resulted in the ceramic vessel s/he received. However, a likely local coarse ware, at least produced in eastern Arabia, might be seen as an incipient transition of technical agency related to Mesopotamian derived ceramics stimulating local inhabitants making their own ceramic vessels (Carter 2010, 191). It can be argued that this was largely *cultural contact without current*, analogous to a conductor and insulator being connected but not producing any electrical current. In this case the ceramic vessel is a conductor of technical knowledge, but this is not transferred as the person or society receiving the vessel does not possess the cultural properties of conducting these currents (insulator). This lack of technical transmission might be due to the insufficient demand for imported goods, or, it was important that the pottery was not-local, enhancing its status among the local population.

During the Ubaid (2-5) period (5th-4th millennium BC), Mesopotamian derived ceramics found their way through barter, trade or down-the-line contact to the Arabian Peninsula (Carter 2006; Carter 2010; Carter 2013; Potts 2005). The quality and quantity of Ubaid related wares seems to drop the further south one goes, and Carter suggests the ceramics at more southern sites are derived through indirect (down-the line) contact (Carter 2010, 191). It is likely that these vessels had particular value because they came from afar, perhaps being tied into the creation of local power or being associated with exotic objects (Carter 2010; Helms 1988). Their decoration and the predominance of open forms suggest they played an important role in local acts of display and feasting (Carter 2006, Carter 2010). Quoting Carter (2010: 197): “It is argued here that Ubaid pottery and its correlated activities (feasting and exchange) had a transformative impact on Arabian Neolithic society, representing a new means of accumulating wealth and prestige within the Neolithic context”. Vessels are clearly dominated by open shapes (bowls) which likely played a role in feasting and social display (Carter 2010).

Carter suggests that they might have been instrumental exchange mechanisms between early seafarers sailing down from Mesopotamia, in obtaining access to intangible goods such as fishing rights (Carter 2010, 199). These object thus had agency in their extrinsic value, being decorated and coming from outside of the local cultural sphere. However, the technical agency of the manufacturer is not recognized at this stage; the technical skills that went into making the object were not visible. However, significantly, attempts to fabricate similar vessels out of plaster are reported from Eastern Arabia (Carter 2010, 195).

The 4th Millennium BC (Uruk period) shows very limited ceramic evidence, save for Tarut island, thought to be an important trading station in Eastern Arabia for products, such as soft-stone vessels, traded between Mesopotamian city-states and areas along the gulf such as south-east Iran (Jiroft) and the Indus Valley (Carter 2013; Collins 2003).

In the Hafit period (3200-2500 BC), imported vessels from Mesopotamia fulfilled a similar role as in the Ubaid period though displaying a different range of shapes. They consist of closed vessels, and are most visibly attested as well-known ceramic vessels in the form of small ovoid necked jars, either painted or unpainted, with

sharply everted rims which have clear parallels in Mesopotamian Jemdet Nasr and Early Dynastic periods, and often were the only ceramic evidence being deposited in Hafit tombs (Potts 1989b; Méry 2000, 170: Fig. 103; 174: Fig. 106). The consistent presence of these types of closed vessels might have been associated with a particular good (perhaps an ointment?) and future research should be targeted at establishing what was contained in these Mesopotamian imports.

It is still debated if these vessels were locally copied and Méry suggests on the basis of petrographic examination and XRF data that they were all imported from Mesopotamia (Méry 2000, 187-189; but see Thornton 2013 who suggests local production as well). Their dominance in tombs might be skewed because of the lack of associated sites, but shows that these exotic objects played a role in local burial rites. This pattern is very much continued in the following Umm an-Nar period. However significantly, the end of the Hafit and onset of Umm an-Nar (around 2500 BC or slightly earlier) sees a change in the situation in terms of the technical agency of these vessels. Imported vessels from Mesopotamia, the Indus Valley and south-east Iran (Makran) are all known in the local assemblages, again featuring mainly in tombs but also known from settlements (most concisely set out by Méry 2000). These ceramic vessels, with their exceptional quality and exotic nature were likely to fulfil an important agency in local negotiations of power, and mediated in the establishment of common ancestors interred in communal tombs (Cleuziou and Méry 2002). Cleuziou (2002) has stressed the mediating factor of such practices such as collective burial in masking hierarchical tendencies. As such they might have become inalienable goods when interred with the ancestors in collective tombs (Mauss 2002; Mills 2004; Weiner 1992). Yet importantly, pottery is also produced locally (Black on Red fine ware) with a skill in terms of clay preparation, forming, decorating and firing that strongly suggests the influence of peripatetic potters from the Makran region introducing technology (Méry 2000) (see further below). In general there might be a good case for itinerant craftspeople in the 3rd millennium BC, as specialised crafts such as metal working, pottery making and tomb building might not have been supported all year round on a local level, but on a wider regional level where craftsmen could offer their services to different communities. A local, regionally different ceramic industry during the Umm an-Nar period is attested in the Sandy Red Ware which seems to be less specialised, in both skill and location, and was likely

related to households or household workshops within settlement clusters (Méry 2000; Méry 2013). It is thus in this period that cultural transmission shows agency from person to person, and ceramic knowledge starts to be transmitted from person to person, and via exchanged objects to persons. As Potts states: “I submit that the shapes, decorations and manufacturing techniques of the earliest Umm an-Nar ceramic repertoire presuppose an experienced and knowledgeable community of potters.” (Potts 2005, 72). This transmission of skills not only occurs in terms of pottery making, but has been connected to the introduction of copper working and oasis agriculture (Tengberg 2012; Cleuziou 2002). It can be seen as part of growing social complexity (Magee 2014). At this stage, a ready acceptance by the local population in adopting new techniques can be attested, leading to relatively rapid technical innovations and complexity in the region (Bortolini 2013).

In the Wadi Suq period, ceramics are attested to be produced locally, and are suggested to be regionalized on the basis of macroscopic fabric analysis and limited petrographic and XRF examination done by Méry (Carter 1997a; Magee 2014; Méry 2000). Imports still feature among the ceramic assemblages, most dominantly connected to Dilmun (Méry 1998). However, the local production of ceramics clearly dominates. This regionalization of ceramic manufacture continues into the Late Bronze Age and Iron Age I (Carter 1997a, 190; Magee 2014). At this later stage the general absence of the wheel, which, as already discussed, was transmitted during the 3rd millennium BC and in use consistently during the previous Wadi Suq period, was substituted by handmade techniques (Magee 2002; Magee 2011). Interestingly, the same development seems to have been attested for the (at least partial) disappearance of the fast wheel at the end of the Middle Bronze Age in the Southern Levant (Magrill and Middleton 2001). One can suggest the use of the wheel is intrinsically connected with the complexity of societies in terms of the organization of crafts. This development was started during the Late Bronze Age (16/1500-1300 BC), when ceramics seem to be cruder in fabric and handmade, continuing into the Iron Age I (1300-1000 BC) with a dominance of handmade coiled vessels and the absence of clear signs of the use of the wheel (Magee 2014, 192; Magee 2011). It has been argued that the level of production is locally organized around households, and non-specialist in nature (Magee 2014, 192). The production is suggested to be largely focussed on the Wadi Haqil, near Shimal (and 7 km from our case study) (Magee

2014, 192). It might be suggested that the clay from this local region has been used for ceramic production at least since the start of the 2nd millennium BC. However, similar general vessel shapes such as spouted jars and bowls, painted in red (iron-oxide) suggest a continuation of practices during this time. In the Iron Age II (1000-600 BC), the ceramic industry seems ‘reinvigorated’ with the use of the slow wheel suggesting another shift in ceramic organization with specialists using the wheel to produce ceramics. This development is continued into the Iron Age III (600-300 BC). The ceramic industry seems to rekindle again with developments in Iran, such as bridge-spouted vessels (Magee 2014, 222; Magee 1996). One could say that these open vessels and spouted jars have a *longue durée* history of being connected with consumption patterns in the Arabian Gulf, going back to the end of the 3rd millennium BC.

5.8.3: Umm an-Nar ceramics and the incipience of Wadi Suq ceramic production

In order to be able to study the evolution of Wadi Suq ceramic vessels, let us now examine in more detail the way in which 3rd millennium BC pottery practices can be seen as ancestral to ceramic practices attested at the start of the 2nd millennium BC. This particular viewpoint has been overlooked due to the assumption of a strong break, and the use of ceramic styles to categorize periods and cultures (see above).

The most detailed treatment of 3rd millennium BC ceramic traditions in the Oman Peninsula remains the extensive work of Sophie Méry (Méry 2000). She identifies two dominant ceramic traditions for the Umm an-Nar period, namely Black on Red fine ware (*céramique fine rouge*) and Sandy Red Ware (*céramique sableuses rouges*) (Méry 2000, 79-168). Both are restricted to the Oman Peninsula. However, important differences in these two traditions likely reflect different organization of pottery production, where Black on Red Fine Ware is a high skill production of fine ceramics both found in settlements and especially in tombs, and Sandy Red ware being a more localized production dominating the domestic assemblage and occurring in some tomb assemblages. It thus seems that in the Umm an-Nar period, pottery production was organised along different levels of specialisation, one being Black-on-Red ware, highly specialised and constricted to a few (or one dominant) workshops, the other being more dispersed ceramic production, with less specialisation and localized to particular settlement areas.

5.8.4: Black on Red fine ware

The general characteristics of the Black on Red fine ware from the Umm an-Nar period are summarized by Sophie Méry (Méry 2000, 101-103). The ceramic vessels are all extremely fine tempered (Méry 2000, 102). To Méry this either suggests mixing of clays of different quality or decantation (levigation). Vessels are not wheel-thrown but there are definite signs for the use of support of a rotary device (Méry 2000, 53-54, 102). The evidence of coiling and wheel-finishing is seen in break-patterns of some vessels. After forming the vessels, the outer body is smoothed and a red firing slip is applied. Subsequent decoration consists of black or brown painted motifs. This class of pottery is well-fired in an oxidizing atmosphere, suggesting the use of kilns (Méry 2000, 101). Good evidence of a kiln derived from Hili where parts of a partly subterranean pottery kiln were excavated, likely a simple updraft kiln (Frifelt 1990). The petrographic and neutron activation analysis of the Black on Red fine ware from Hili shows that it likely derives from the same zone of production, if not a single workshop (Méry 2000, 110).²⁶

5.8.5: Sandy Red Ware

This ware category is clearly distinguished from Black on Red fine ware in terms of clay and temper, and in terms of technological tradition, and must be seen as a separate ceramic tradition within the Umm an-Nar (Méry 2000, 169). Méry states that in no way should Sandy Red Ware be seen as a coarser variant of Black on Red Ware, or the latter as a more levigated type of Sandy Red Ware (Méry 2000, 168). The clay fabrics differ from site to site (Hili, Bat/Amlah, Maysar, Ra's al-Jinz), with the Sandy Red Ware of Hili showing a broader distribution, and share a paste characterized by iron-bearing clays with little carbonate and abundant sandy temper (Méry 2000, 168). The ceramic vessels were produced with the use of the wheel, and careful examination of the production traces together with experimental studies have shown that the wheel using technique to finish coil-built vessels was in decline at the end of

²⁶ Importantly, a macroscopic fabric group (rs2) is recognized within the Black on Red ware as a minority in Hili tomb A, being richer in sand and characterised by fine mineral temper (smaller than 0.4 cm), with a pink colour (beige rose a rose) and the absence of dry-cracking (thus perhaps less lean clay) (Méry 2000). This might show a change in the preparation of clay within the quite homogenous Black on Red ware tradition, perhaps to counter the effects of dry-cracking.

the 2nd millennium BC at the site (Méry *et al.* 2010; Méry 2010). This ware is dominant in domestic assemblages, and represents a fair part of funerary assemblages (most notably Tomb Hili N: Méry 2000, 125; McSweeney 2010). It is studied in most detail for the site of Hili, and the production is seen as local, although not specifically pinpointed to a certain site (Méry 2000, 169). However, its presence in the tomb assemblage of Tomb A of Hili North is very relevant for our discussion of ceramic production and continuity into the Wadi Suq period, as this tomb is considered to be a late Umm an-Nar circular tomb (Méry 2000, 168; McSweeney *et al.* 2008, 10) (see **Fig. 5.2**). This may prove important as it might show a shift of this ware from the domestic sphere to the funerary environment. The shift from domestic to funerary sphere might be further corroborated when more late Umm an-Nar tombs are excavated and studied. Moreover, this shift might indicate that potters hitherto focussed on making ceramics for domestic functions, now provided vessels that were incorporated in the funerary assemblage, at least at some stage in their use-life. Although thus far it has not been specifically addressed as such, it might provide important insights into a shift in the dynamics of ceramic production at the start of the 2nd millennium BC.

From a stance of Umm an-Nar ceramic production as an ancestor to Wadi Suq ceramic production in the following millennium, the distinction between these two demarcated ways of producing ceramics is essential in understanding the continuity and discontinuity of ceramic production into the Wadi Suq period. At this point, we might already argue that the highly specialised ceramic production (Black-on-Red) did not continue but some elements were incorporated in the more dispersed ceramic production already attested in the Sandy Red Ware ceramic production. It might thus be hypothesized, that in a simple scheme, the regional production as attested in Sandy Red Ware was continued, incorporating elements (especially in decorative patterns) attested in Black-on Red fine ware production.

However, the attestation that Sandy Red Ware contains few carbonates is in contrast with the dominance of calcium carbonates visible as macroscopic inclusions in Wadi Suq fabrics attested at both Qarn al-Harf and Shimal. Nevertheless, in a recent report, Sandy Red Ware and Wadi Suq wares are treated as a single fabric for the site of Tell Abraq (Magee *et al.* 2015). This suggests that at least in some locations, such as the sites of Shimal, Dhayah and Qarn al-Harf close to northern part

of the Hajjar Mountains dominant in dolomitic limestone, (Ru'us al Jibal: (Glennie 1974; Méry 2000, 27-38), a 3rd millennium BC way of organizing ceramic production might have continued into the 2nd millennium BC, but the exact manner of procuring clay and temper, and preparing clay is not a direct continuation. This break needs further study. However, at least two fabrics attested at Qarn al-Harf are very sandy, and fire to red/red-purple hues under oxidizing firing (Fabric 3 and 4), suggesting a similarity in fabric with the Umm an-Nar predecessor.

5.8.6: Evidence for continuity of ceramic traditions between Umm an-Nar and Wadi Suq

Another tantalizing glimpse of ceramics transitional from Umm an-Nar to Wadi Suq comes from Idhn (tomb IN5), the transitional round subterranean tomb discussed above. For this tomb, the continuity in architectural traditions of tomb building is paralleled with evidence for ceramic continuity where: “The pottery vessels are altogether unusual too. The paste of several spouted jars is a *buff sandy porous fabric matching well with the pottery found in Umm an-Nar settlements* [italics mine]. The painted decoration, however, lies well within the expected production of the Wadi Suq pottery.” (Vogt 1998, 278-279). This is in line with our expectations that clay recipes are quite conservative in nature and do not easily change (§2.4.6). Thus here we may have attested the continuity of this ‘buff sandy porous fabric’ into the WS, which we might perhaps equate with Méry’s Sandy Red Ware, though future petrographic analysis could confirm this stance.

5.9: Wadi Suq ceramics

In general, far less is known about Wadi Suq ceramic production than its Umm an-Nar antecedents (Méry 2000). However, the ceramics form a clearly distinguishable corpus with particular technical features and decorative motifs. This ceramic corpus or style was first recognized by Karen Frifelt who called it ‘Wadi Suq’ after the *wadi* behind Sohar where tombs of this period were found (Frifelt 1975). This period is known from a limited set of settlement sites (Abraq, Kalba, Nud Ziba, Ra’s al Jinz: Carter 1997a; Potts 1990b; Potts 1991; Monchablon 2003). The majority of our ceramic evidence comes from a considerable number of tombs such as Wadi Suq, Samad al-Shan, Shimal, Jebel Buhais, Dadna, Mereshid, Qarn al-Harf (see map: Fig.

5.1), of which the biggest assemblages are from Shimal and Qarn al-Harf (Benoist 2002; Jasim 2012; Velde 2003; Velde *forthcoming*; De Vreeze 2016b; Yule 2001).

5.9.1 General characteristics of Wadi Suq ceramics

Magee concludes: “Metalwork and soft-stone and ceramic production follow, therefore, a similar trajectory in which production is diversified and the foreign models that had influenced production in the third millennium BC are rejected in favour of a local and distinctive repertoire” (Magee 2014, 186). However, thus far, not enough attention has been paid to what these changes in the ceramic repertoire reflect. Hence, an important opportunity is missed to explore the change in consumption patterns. In other words, not enough attention has been paid to the simple question of why there is a dominance of small open vessels (beakers/cups) and spouted jars ideal for pouring liquid substances.

Thus far, the following characteristics have been seen as typical for the Wadi Suq ceramic industry (**Fig. 5.8**):

- An important increase is seen in the number of ‘spouted jars’ and beakers and cups, specifically in tomb assemblages (de Cardi 1988). A third group consists of small closed jars (sometimes called miniature jars), reminiscent of some Mesopotamian shapes and sometimes related to ‘Dilmun’ imports (De Vreeze 2016b).
- Other ceramic shapes include larger storage jars (particularly at settlements, and open vessels such as bowls (Carter 1997; Cleuziou and Righetti; Potts 1990b; 1991).
- String-cut bases (Potts 1990b, 60; Méry 2000, 270; **Fig. 5.9**). However, they also occur in Umm an-Nar period (see below).
- Quite heterogeneous fabrics suggesting localized production (Méry 2000; Méry 1990b).
- Vegetal temper is more dominant than in the previous Umm an-Nar period (Méry 2000; Carter 1997), with a gradual shift to more vegetal dominated temper, but mostly dominant for the later Wadi Suq and Late Bronze Age.
- The incomplete oxidization of firing attested in many vessels (Méry 2000, 270-271; also attested at Qarn al-Harf).

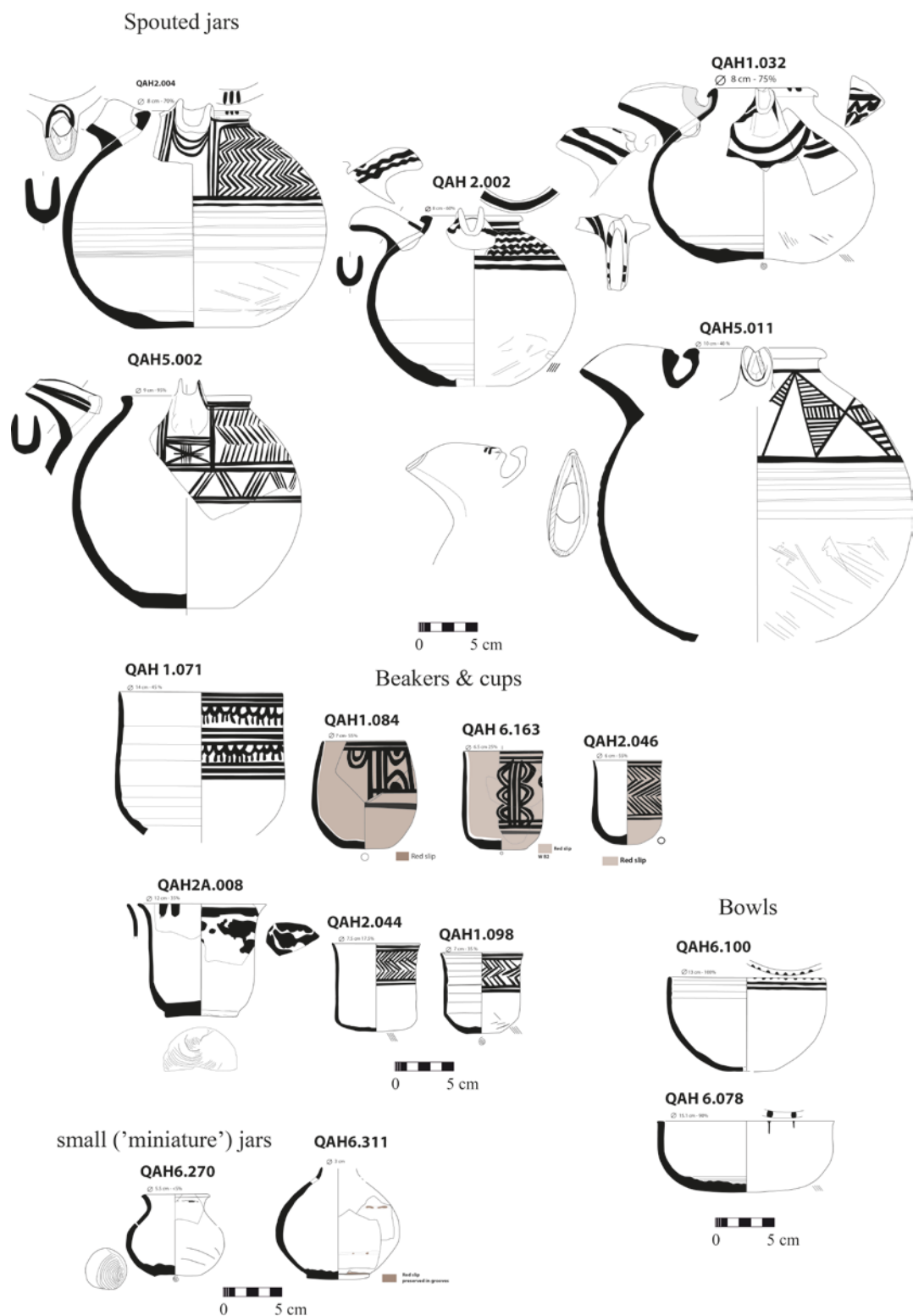


Fig. 5.8: Typical Wadi Suq ceramic assemblage based on vessels found at Qarn al-Harf consisting of spouted jars, beakers & cups, small ('miniature') jars and bowls (provided scale is 5 cm) (drawings by De Vreeze in Derek *forthcoming*).

- A clearly recognized set of painted decoration using loops, lines and hatched triangles, ubiquitous zigzag chevrons and wavy lines, and a limited set of anthropomorphic and animal motifs (**Fig. 5.8; Fig. 6.2**).

5.9.2 Wadi Suq Fabrics

Although Méry treats Wadi Suq ceramics in a separate chapter (Méry 2000, 249-271: Chapter 8), this treatment is far more brief than the chapters on Hafit, Umm an-Nar and the imported traditions. However, based on the limited evidence at hand at the time (Hili 8 settlement), and Shimal tombs and settlement, she was able to attest to a significant shift in clay-sources used in the Wadi Suq period (Méry 1991b). Nevertheless, Méry states the similarity of some Wadi Suq sherds with the Red Sandy Ware tradition at Hili (Méry 2000, 254). The vessels show considerable heterogeneity in minor non-plastic inclusions (Méry 2000, 265). The most distinguishing feature of the Wadi Suq ceramics examined by Méry is the addition of vegetal temper (Méry 2000, 254). Moreover, incomplete oxidization of the vessel is frequent (Méry 2000, 270-271). Petrographic examination of a number of 28 sherds by Méry, shows one sherd with similar petrography to Sandy Red Ware at Hili. Méry stresses the heterogeneity of the Wadi Suq fabrics, something which is also evident at the material of QAH (up to 17 fabrics, with further subdivisions) and which led Christian Velde to withhold from detailed fabric descriptions (Velde *forthcoming*). The fact that local fabrics can be unique and should be related to the geographical peculiarities of the production areas is attested at a number of tomb assemblages. For instance, a unique fabric is attested at Dhayah, being ‘greenish in colour and used for spouted jars and beakers. It is tempered with small reddish stone grits, but the shape and decoration of the pots are typical of the Wadi Suq Period in Shimal.’ (Kästner 1991, 238)

Important conclusions can be drawn on the basis of Méry’s (2000) preliminary work. Due to geographical proximity and geological similarity, the detailed study of fabrics from Shimal can likely be partly extrapolated to the site of Qarn al-Harf. It is significant in geological terms that the tombs of Shimal, Dhayah and Qarn al-Harf are found along the Northern part of the Hajjar mountains (Ru’us al Jibal) where limestones and dolomitic limestones dominate, with argillaceous limestones as minor component (Gouldie 2011, 110). Méry (2000, 271) attests to continuity in the use of

clay sources in this northern region, whereas a discontinuity is seen in the use of local clay in the Wadi Suq period at Hili. The Wadi Haqil, close to Shimal, is known to have been an area of pottery production from at least the Iron Age up to around 1940 (Magee 2011; Lancaster 2010). This means the Wadi Haqil would be the most likely source for pottery from Shimal, including the Wadi Suq vessels from the tombs. However, no evidence of Wadi Suq pottery workshops has been found so far. This geological difference probably played a role in local shifts in pottery production. More detailed analysis is needed to show if particular developments are less visible at more southern sites, where the geology is dominated by ophiolites (Méry 2000; Glennie 1974). It might be suggested that the phenomenon of 'lime spalling' (Rice 2005, 98) became a particular concern for potters of the Wadi Suq period producing vessels from the lime-rich clays in the northern Emirates.

It was Carter (1997a: 213) who already noted: "Thus, the styles and technology of production of the two assemblages were held in common, but the vessels were locally made using materials from various nearby sources." He attributes the lack of standardization in fabrics to an 'opportunistic' selection of clay sources, and suggests that ceramic production was in the hands of a number of potters or groups of potters within a particular region, thus not being very specialised (Carter 1997a, 213). This is in line with the evidence from Shimal, where Christian Velde has been reluctant to develop fabric groups due to the heterogeneous nature of the fabrics themselves (Velde *forthcoming*).

The study of ceramics at Qarn al-Harf by the present author did yield possibilities to develop fabric groups, examining the breaks by naked eye or hand-held lens. Notwithstanding, it made heterogeneity of the fabrics, as remarked by previous scholars, apparent. Despite this heterogeneity, up to 17 different fabrics were recognized, related to the general colour of the matrix, and the size and nature of the temper. However, even within these fabric groups, further subdivisions show the heterogeneity of the fabrics. Moreover, having seen a selection of the Shimal ceramics in the local museum of Ras al-Khaimah made it apparent that the fabrics from Shimal, with a similarly large assemblage of vessels from various tombs did not show the full range of fabrics recognized at Qarn al-Harf, suggesting again that local clay sources and ways of preparing the clay underlie a more homogenous way of producing and decorating the vessels. This difference between two nearby sites also suggests that the

vessels from Qarn al-Harf might have been produced using a different clay source and tempering agents from the one used at Shimal (probably wadi Haqil in latter case). This again emphasises that the collection of clay and preparing of clay is most regionally specific and less copied, except for general appearance, for instance due to manipulation of the firing regime.²⁷

5.9.3 Technical features attested at Qarn al-Harf

Technical features typical of Wadi Suq ceramics have recently been summarized by Christian Velde (Velde 2003, 104-105). However, after studying the material from Qarn al-Harf, and comparing it with recent literature, I think there needs to be some reconsiderations about the potters' techniques, especially concerning the use of the wheel.

String-cut bases and the use of the wheel

String-cut bases are seen as distinct feature in the Wadi Suq, as they are a rare but present feature in previous Umm an-Nar period (Cleuziou 1981, 282). String-cut bases are already attested in Umm an-Nar period, for instance in an Indus import from tomb A at Hili Nord (Méry 2000, 54. Fig. 26: Vase V234). The same vessel shows a spout on the shoulder, which is in general quite rare in the Umm an-Nar period. Moreover, cups or beakers with string-cut bases are 'not so late or few in number' at the settlement of Umm an-Nar (Frifelt 1995, 153). A clear example in 'Red sand-tempered ware' from Umm an-Nar might indicate string-cut bases related to Sandy Red ware, although Frifelt states that for the majority of cups and beakers, they do not seem to be part of either Black on Red ware or Sandy Red ware (Frifelt 1995, 154; 1991: Fig. 134) This suggests that string-cutting such small vessels from a rotary device (or hump of clay) was already well practiced in the Umm an-Nar period, whether relating to Indus valley ceramic practices or not. Moreover, the technique is well attested in contemporary Mesopotamian traditions (Armstrong and Gasche 2014).

²⁷ A large scale petrographic study (combined with Neutron activation/XRF) of a few key assemblages of Wadi Suq ceramics should be able to clarify the local nature of pottery production (tied to local clay sources), and perhaps pinpoint to their particular geographical location.



QA6.131: smoothed but string-cut faintly visible.



QA5.089: String-cut and shaped/scraped sides.



QA2.064: String-cut base.



QA1.076: Possible miniature coiling and wheel-finishing.



QA5.027: Bases of larger (spouted) jars often break off at the transition to the wall. Where the first coil was added. These bases were separately made first with coils added to build the wall.



QA6.078: concentric rilling inside jar. Wheel-made/finished.



QA1.169: Spiralling finger traces. Signs of wheel-turned production.

Fig. 5.9: Examples of the finishing of bases attested at Qarn al-Harf. The bases show clear evidence of the wheel and removing smaller vessels from the wheel or hump of clay with a string (upper left examples) (Figure prepared by M. de Vreeze in Derek *forthcoming*).

The assumption that string-cut bases relate to foreign influences, as has often been suggested, is problematic (Potts 1990b, 61). It might be better to see string-cut bases as representing a ceramic industry that makes use of a rotary device, and has a fairly rapid production process where (small) vessels are cut from a rotary device or from a larger body of clay on such a device, and left untreated afterwards (**Fig. 5.9**). Thus, direct transmission does not have to be assumed, but parallel development in ceramic production and its organization may be implied.

As will be argued in this chapter, the assumption of a ‘total rupture’ between Umm an-Nar and Wadi Suq is no longer tenable and obscures essential hints of continuity in ceramic practices, in line with continuity argued from other lines of evidence. Although new types of ceramics become dominant, these categories of vessels can have rare antecedents in the Umm an-Nar period. More likely, we can speak of a reorientation of ceramic production, already attested in the reorientation of used clay-sources. The change of ceramic tradition in the Wadi Suq must be sought in the change of organisation of ceramic production, geared towards more local, less centralized ceramic production, together with a shift in emphasis of particular types of vessels, which seem to become essential for human interaction, especially in the realm of funerary practices (beakers/cups and spouted jars).

5.9.3: The *chaîne opératoire* of Spouted jars, beakers and cups as attested at Shimal and Qarn al-Harf

Christian Velde has paid particular attention to the differences in technique as shown on the ceramic corpus from the multiple collective tombs at Shimal (Velde *forthcoming*). In his work he already established important features which he supposes show chronological differences, such as the placement of the spout, and the use of the wheel and general finishing of the vessels. However, I believe he interprets some of the features from an anachronistic stance, which I believe comes forth from an assumption of the use of the wheel. Particularly for jars and spouted jars, he suggests that a flat separate base was added after the vessels are produced on the wheel, by cutting away the old base and applying a separately made base (Velde *forthcoming*). On the basis of the study of material from Qarn al-Harf, and comparison to recent discussions on the use of the wheel (see chapter 2) I think this sequence has to be augmented. However, much information on the general

morphology, surface treatment and decoration has been incorporated in the descriptions and drawings.²⁸ The ceramics from Qarn al-Harf can show different degrees of using the wheel, from wheel finishing coiled vessels, to likely fully throwing smaller vessels such as beakers and cups (off the hump). The use of the wheel seems to have gone through profound periods of experimentation at the site, perhaps similarly to other locations in the north of the Emirates such as Shimal and Abraha (Velde *forthcoming*, Potts 1990; 1991). Importantly, the differentiated use of the wheel within the Wadi Suq period is in need of further detailed study, perhaps using experimental studies and more careful examination of the production traces.

Wadi Suq vessels can have varying degrees in which the string-cut of the base is obscured by later scraping, smoothing and slipping the vessel (see **Fig. 5.9** above). This element of smoothing the vessel and removing manufacturing signs on the outside of the vessel is a key characteristic which changes throughout the Wadi Suq, as in the later period this step is omitted and bases are left untreated after cutting from the main body of clay. However, this pattern might not be purely chronological. At Abraha (Potts 1993) string-cut small vessels are clearly attested in late Umm an-Nar tomb. It thus suggests that this technique was in use at the time. The visibility of string-cuts seems to depend on the decision of potter to either obscure the marks or leave them as visible on the vessel.

5.10: Explaining the homogenous features of Wadi Suq ceramics

What explains this homogeneity in ceramics, and other artefact groups over a stretch of hundreds of kilometres into diverse geographical pockets and across separated communities, leading us to talk about a ‘Wadi Suq’ culture? Similar shapes and decorative patterns are attested from Ghalilah to Masirah island, but were likely produced locally, although this has to be further tested with petrographic and chemical studies. Basically, we can ask ourselves how this ‘standardised vocabulary’, as Carter calls it, of ceramic making was transmitted through the Oman Peninsula (Carter 1997a, 86). A number of options might be suggested and are worth exploring further in the future, not to be seen as mutually exclusive.

²⁸ Unfortunately the material from Qarn el-Harf was relatively fragmented, but many vessels could be assembled from the fragments. However, the interpretation and drawings have been done on the basis of fragmentary vessels, taking as much information from the fragments as possible. However, the resulting drawings will be too symmetrical and do not reflect the irregularities in profiles enough.

Option 1: pots travel, with the object having agency and capability of transferring technical knowledge (copying of traits) (§2.5.1).

Option 2: potters travel: within the 2nd millennium BC, people with knowledge of pottery making travelled over longer distances, or found new communities to live and work in, perhaps along the lines of lineages or newly started families (creating family ties, women as potters finding new communities after marrying?). Traveling potters working for multiple communities?

Option 3: Users travel: people travel across the Oman Peninsula in the 2nd millennium BC and incorporate new ideas observed at other communities and these are communicated when returning to their own community.

All three options should be kept in mind when talking about transmission of ceramic traditions. However, more detailed analysis might show that communal features between distant communities mostly entail general morphology and decorative patterns that might be copied easily, without copying the exact *chaîne opératoire*. This goes back to Gosselain's ideas of difference of transmission on the basis of visibility of ceramic features (§2.5.1). This would suggest that the more easily recognizable (visible) a technical feature is, and the easier it is to produce in terms of technical difficulty, the higher the chance that it will be copied by potters working in different traditions, and spread over a wider area. Vice versa, the less visible a ceramic feature is, and more difficult to reproduce technically, the harder it will be to copy outside of a particular community of practice.

5.11: Causes of change in ceramic production between Umm an-Nar and Wadi Suq period

To summarize, we might suggest that the changes which occur in ceramic production between the Umm an-Nar period and Wadi Suq relate to a continuous pattern of change in the relation between ceramic use and production within society in the Arabian Peninsula. As has been suggested, ceramics were mainly an imported product within the Ubaid and Hafit period (4th millennium and start of the 3rd millennium BC); either for their intrinsic value, for their actual contents, or both. However, with the onset of the Umm an-Nar period, local production is attested with a specialised, high technical level from its incipience, and good parallels with foreign produced ceramics

(Pakistan/Makran and Iran) suggest the potters were at least partly non-local potters from these foreign regions.

Nonetheless, within the onset of the Umm an-Nar period, a duality in production has been suggested, with the finely made Black on Red ware being a highly specialised product perhaps only produced in a few or workshops; and more regional production of Sandy Red ware, such as is attested at Hili and other sites. The production of Sandy Red Ware suggests a shift towards a larger number of local producing groups of potters, whether in workshops or specialised households at the end of the Umm an-Nar period. It might be suggested that this branching towards local production is continued in the Wadi Suq, with the transmission of ceramic practice at the end of the 3rd millennium BC both through the production at different local workshops. Thus this system of practice persists, with continuity in decorative motifs based on motifs used in the Black-on-Red fine ware production of the Umm an-Nar period.

The above synthesis leads to a preliminary hypothesis that the transmission of ceramic traditions was dual in nature, with the localized production based on the wheel being used to finish predominantly coil-built vessels, inherited from a similar way of organizing the production of Sandy Red Ware. The transmission would have been between individuals within workshops, with continuity of transmission between (household) workshops. Moreover, decorative patterns from the highly skilful production of Black on Red fine ware tradition were transmitted within a new framework of Wadi Suq production.

Chapter 6

The evolution of spouted jars and beakers/cups at Qarn al-Harf

6.1 The ceramic corpus

The phylogenetic case-studies will mostly be based on the material studied during recent rescue excavations (2012, studied over the course of several months in 2013) at Qarn al-Harf, located in the Emirate of Ras al-Khaimah. Over 70 tombs dating to the Wadi Suq and Hafit period have been recognized at this site, with tombs lying along the alluvial plain of a small free-standing mountain range separated from the nearby Hajjar mountains (Hilal 2005, Kennet *forthcoming*)

During a rescue excavation conducted by Durham University with the cooperation of the National Museum of Ras al-Khaimah, 10 tombs were excavated. These tombs consisted of Qarn al-Harf QaH1: 4 heavily disturbed tombs on a ridge; QaH2: a ‘Shimal-type’ long tomb; QaH5: an oval-shaped type with double internal walls (so-called *Ghalilah type*); and QaH6: a sub-circular tomb with internal divisions in the form of two walls attached to the side. Later tombs and features excavated consisted of a Shimal-type elongated tomb with lower floor (QaH2A); a circular stone structure, heavily plundered, possibly of Hafit-Umm an-Nar date (QaH5A); and a small subterranean cist-tomb (QaH5B) (Kennet *forthcoming*).

The ceramics of QaH1, 2, 2A, 5 and 6 proved to be very fragmentary due to repeated use of the tombs for consecutive burials, later reburials (Iron Age and recent Pre-Islamic period) and possible looting. Nevertheless, a large number of sherds could be re-assembled (refitted) into vessels, with clues provided by shared context, physical fits and unique combinations of technical features and painted designs. As such the vessels could be studied and drawn (see **Fig. 5.8**).²⁹

²⁹ The vessels were rarely glued because of the fragmentary nature, size of the assemblage and lack of time. Instead a policy was adopted of drawing the vessels on the basis of the composite profile using representative fitting sherds which added up in profile and decorative pattern and selecting fragments of the vessel that could yield the most complete information on the profile, technical features and decorative motifs, combined into one drawing.

Tomb /Vessel Type		QAH1		QAH2		QAH2A		QAH5		QAH5B		QA H6*		Total	
	#/%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Open	Bowls	4	2.2					1	0.6			8	2.6	13	1.7
	Beakers	31	16.9	10	11.9	6	28.6	35	20.3			41	13.6	123	16.1
	Cups	80	43.7	34	41	8	38.1	68	39.5	2	100	135	44.7	327	42.8
Closed	Storage jars	3	1.6	2	2.4			2	1.2			1	0.3	8	1
	Spouted jars/ jars	48	26.2	32	38.1	5	23.8	52	30.2			99*	32.8	236	30.9
	Medium jars	1	0.5					2	1.2			2	0.7	5	0.65
	Miniature jars	12	6.6	5	6			11	6.4			13	4.3	41	5.4
	Suspension jars					1	4.8							2	0.3
Other	Lids	1	0.5					1	0.6					2	0.3
	Uncertain	2	1	1	1.2	1	4.8							7	0.9
Total		183		84		21		172		2		302		764	

Table 6.1: Quantification of types approximate for tombs at Qarn al-Harf. The tombs of QAH1 are grouped together in this table. The numbers of QAH6 should be taken as an approximation, not counting up to 50 small rim fragments of (spouted) jars. However, the relative frequently might be taken as an approximate.

Table 6.1 represents the quantification by tomb. This is done on the basis of identified unique vessels represented, with the addition of unique rim sherds of open and closed vessels (to eliminate double counting). Quantification on the basis of EVE's was opted against because a large number of vessels were fairly complete after assembling the fragments, but lacked rim sherds which could not be identified in the excavated tomb assemblage, and would thus have been discounted in the process skewing the quantification. Moreover, in rare cases fragments from the same vessel could be shown to have been deposited in different tombs (a pattern repeated in the soft stone vessels). This suggests that in some cases vessels were dispersed between tombs after fragmentation. These quantifications must thus be seen as an approximation due to the severely fragmented state of the assemblage, but should be consistent between the tombs and are thus taken to reflect real patterns of distribution of certain vessel types. From the ceramics excavated and analysed from these tombs, in conjunction with previous research on Wadi Suq ceramics vessels, two classes appear to show particular signs of descent with modification through time, with chronological

developments already suggested for the very similar assemblage of the nearby sites of Shimal and Dhayah (Velde *forthcoming*).

The excavated material from Qarn al-Harf posed a good opportunity to test the assumption of ceramic evolution within the Wadi Suq period. In using phylogenetic methods to study a fragmentary assemblage, it was thus possible to test the method with a ceramic record not based on complete vessels (often archaeological reality). In doing so, the testing of evolutionary patterns for these two vessel groups can a) help to show chronological developments of ceramic production and b) contextualize the evolutionary patterns in terms of social, economic, and environmental changes. Two dominant classes of ceramics in the 2nd millennium BC Wadi Suq funerary assemblages are used for this study: spouted jars on the one hand, and cups/beakers on the other. These are the most numerous forms in the archaeological assemblage and show features which suggest descent with modification leading to changes over time.

6.2 Groups of vessels: Beakers, cups and spouted jars

As often occurs within ceramic assemblages, there is a perceivable selectiveness in the ceramic assemblage from funerary sites compared to ceramics from contemporaneous settlement sites. This is no different for the Wadi Suq ceramic assemblage (Righetti and Cleuziou 2010; Carter 1997a). As Velde attests on the evidence of the tomb assemblage, beakers and spouted jars dominate the funerary assemblage (Velde 2003, 104). From a settlement perspective, Righetti and Cleuziou point out that for the Hili 8 settlement assemblage, ‘open flat bowls, storage jars, and (cooking) pots are typical settlement shapes, while beakers, bowls, spouted jars, and miniature jars or small pots are found in both funerary and settlement contexts’ (Righetti and Cleuziou 2010, 290). The excavations at the settlement site of Kalba on the eastern coast of Oman show the same pattern in terms of settlement assemblage (Carter 1997a). As we will discuss further below, the evolution of the shapes analysed in this case study might be driven, to a considerable extent, by changing needs in mortuary practices. However, as attested for other periods, this dichotomy is not absolute. Sometimes we find storage jars in tombs, and beaker and spouted jars in settlement contexts. The reason for this dichotomy has nevertheless not been sufficiently addressed. Answers might be sought in the difference between an

assemblage geared towards storage in general, and preparing and consuming of foods and drinks, and a funerary assemblage which seems to stress the latter; namely the serving and consumption of foods, and even more dominantly: drinks. This emphasis can also be seen as essential to the funerary activity, where communal consumption probably played an important role in the reestablishment of group ties. We will come back to this issue at the end of this chapter and in the final discussion.

6.3 Phylogenetic analysis. Character coding and the Umm an-Nar ‘ancestry’

6.3.1: Character coding

The character coding is based on recognized technical decisions in forming, finishing, decorating and firing the ceramics - as in the case study on Tell el-Yahudiya ware. A challenge lies in the fragmentary nature of many vessels. Yet the ability of phylogenetic methods to deal with such fragmentary data is crucial to the method's success, as fragmentary data is the norm for much of the archaeological record. If phylogenetic methods can not address such data, they will be of limited use in archaeological practice.³⁰ The fragmentary nature of the ceramic assemblage results in the absence of detailed metric data at this point (because of reconstruction drawings, and standardization of measured rim-diameters). A second issue is the variability in shapes within the broader categories. The coding of characters will be further discussed below at the relevant analytical sections.

6.3.2: Umm an-Nar ancestors

As previously discussed, there are a number of technical features in the Wadi Suq ceramic tradition at Qarn al-Harf which suggest an Umm an-Nar ancestry. The use of the wheel is attested in local production from the Umm an-Nar period (see above, at Hili-N), yet the way the wheel was employed suggests that the wheel was likely not used for throwing, but used to finish coiled vessels (Méry *et al.* 2010, see §2.3.2). This might suggest that the potters were not fully specialised as attested in the use of the wheel to create vessels, specifically towards the end of the Umm an-Nar period, when a devolution in technique is observed, at least at the site of Hili (Méry *et al.* 2010).

³⁰ Importantly, the same challenge of fragmentary data for phylogenetic methods does not warrant against their use in reconstructing biological evolution on the basis of fossil data.

It is thus likely that the use of the wheel was transmitted by communities of potters at the transition of the 3rd and 2nd millennium BC but that the way the wheel was employed consisted of coiling and wheel-finishing, not the technique of throwing the vessels fully on the wheel. It may be hypothesized that there was continuity from Umm an-Nar to Wadi Suq in terms of ceramic organization being at the level of local groups of potters working close to settlement/tomb areas, perhaps in part-time capacity in conjunction with seasonal labour regulated by climatic conditions. Although in the case of Qarn al-Harf, 'Sandy Red Ware' cannot be directly shown to be an ancestral ware to the following Wadi Suq ceramics (more detailed petrographic analysis in particular might help establish this continuity). A hypothesis which remains to be tested is the suggestion that the manner of organizing ceramic production in the Wadi Suq period was less specialised in terms of space and organization than the 'Black on Red' fine ware tradition, and produced on a regional scale.

Next to the possible continuity in ceramic organization, there is also evidence for continuity in the use of certain decorative motifs. These motifs were used during the 3rd millennium BC to decorate the 'Black on Red' fine ware, which was a highly specialised production which likely did not continue after the Umm an-Nar period. Nevertheless, the actual decorative motifs themselves might have been transmitted by potters into the Wadi Suq period, using similar designs. This is presumably because the decoration was highly visible and relatively easy to copy by potters separated by both geographical and chronological distance (see §2.4.9).

Thus, the break with Umm an-Nar ceramic traditions in the following Wadi Suq period has been seen as relatively abrupt, evidence exists of continuity in ceramic practices. The changes reflected can perhaps be seen as changes in the organization of ceramic production, or perhaps even a new 'blend' of two previously separated traditions. Below we shall look at the ceramic characteristics which are seen in the Umm an-Nar corpus and find resonance in the Wadi Suq period. These features are highlighted here because they might play a role as ancestral traits.

6.3.3: Ancestral painted motifs attested at Qarn al-Harf and other sites

Ibex (caprid) motif

Stylised horned animals with long bent horns play an important role as a decorative motif on ceramics from the 3rd millennium BC, especially the necked jars of Black on Red fine ware (Méry 2000, 88: Fig. 54.10, 88: Fig. 56.1) (**Fig. 6.1**).

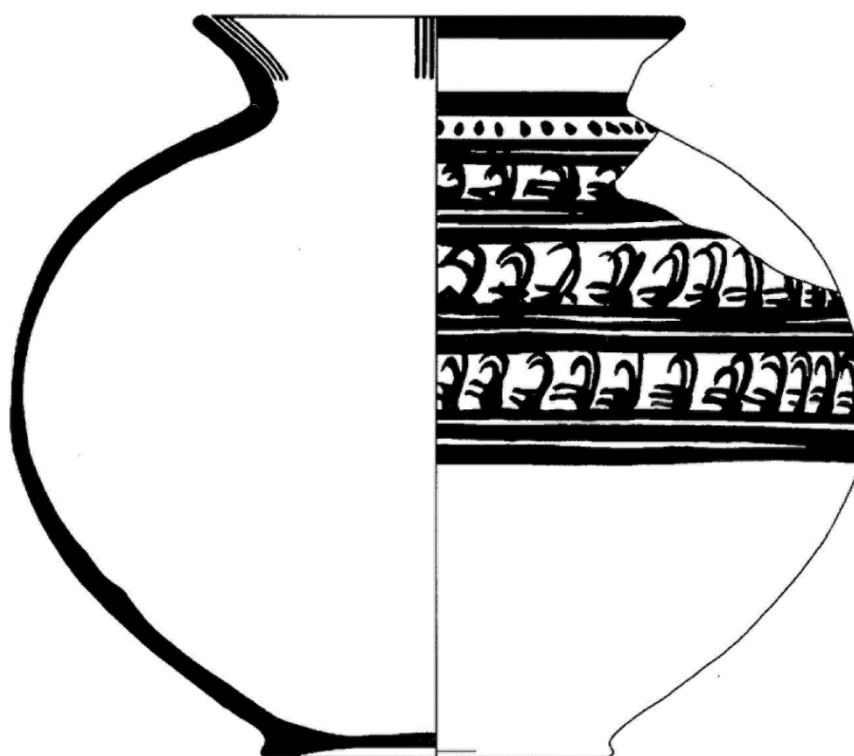


Fig. 6.1: Umm an-Nar vessel with stylised caprids from Hili (after Méry 2000, 91: Fig. 56.1: not to scale)

They are also dominant on fine grey painted ware (*céramique fine grise peinte*) found in the Oman Peninsula during the 3rd millennium BC, though these likely originated from ceramic industries in south-east Iran and Pakistan (Makran region and Baluchistan: Méry 2000, 196: Fig. 122; 198, 204). The ultimate origin of the design might thus be found in the ceramic traditions of south-eastern Iran and Pakistan, being transmitted to south-east Arabian potters in the Umm an-Nar period. The animal represented might likely represent a species of *capra*, such as an Ibex (*Capra nubiana*), a species indigenous to the Arabian Peninsula. A jar from Maysar of likely

3rd Millennium BC date also yields decoration of at least two painted caprids (Weisgerber 1980, 103: Abb.73.3). An example from a 2nd millennium BC context is found at the Dilmun settlement of Saar, but assumed to be of a south-east Arabian origin (Carter 2001, 188: Fig. 4). Two vessels at Qarn al-Harf show painted decoration with caprid motifs. QAH6.002 was heavily and dispersed throughout the tomb with the majority being associated with bone layers in the eastern chamber.

The vessel was of a particularly fine fabric (fabric 16) very reminiscent of the fine Black on Red ware of Umm an-Nar vessels. The slip (2.5YR 4/5 = reddish brown-red) was well applied. Decoration was applied with a particularly fine brush and consisted of caprids (ibexes) perpendicularly positioned, in one case eating from a branch, with birds underneath eating from the same branch. Although the vessel was very fragmentary, enough sherds could be found to show that the motif of caprids facing each other was being repeated on the decorative panel. The globular shape and attachment for a spout shows that the vessel belongs to the Wadi Suq tradition. Thus, it is of great interest to note that a vessel with caprid decoration from Wadi Suq is also reported to be of a 'slightly finer and harder ware than the rest of the Suq pottery' (Frifelt 1975, 380; 409: Fig. 20b). The fabric of this vessel stands out, like with QAH6.002 for the Qarn al-Harf assemblage. QAH1.011 is another vessel which shows ibexes incorporated in the decoration in a free-range pattern. Four probable ibexes with long curling horns are arranged in a procession between a panel of horizontal lines (**Fig. 6.2**).

Other decorative motifs between the animals are hard to identify. The vessel is of a globular shape with a thin rim and a tubular spout is attached to the shoulder. The fabric of the vessel (Fabric 13) is a medium soft, gritty, sandy fabric, and particularly rich in CaCO grits. Significantly, both QAH6.002 and QAH1.011 form part of a group of jars, either with (preserved) spout or without. This group comprises jars which stand out from the corpus of jars and spouted jars in terms of their morphology, decorative motifs, and fabric, together with QAH1.008 and QAH1.017. All show a globular form with thin inward facing rims and when spouts are present, they are positioned on the shoulder of the vessel. They can thus be suggested to be part of an early tradition of Wadi Suq vessels showing clear links to Umm an-Nar antecedents.

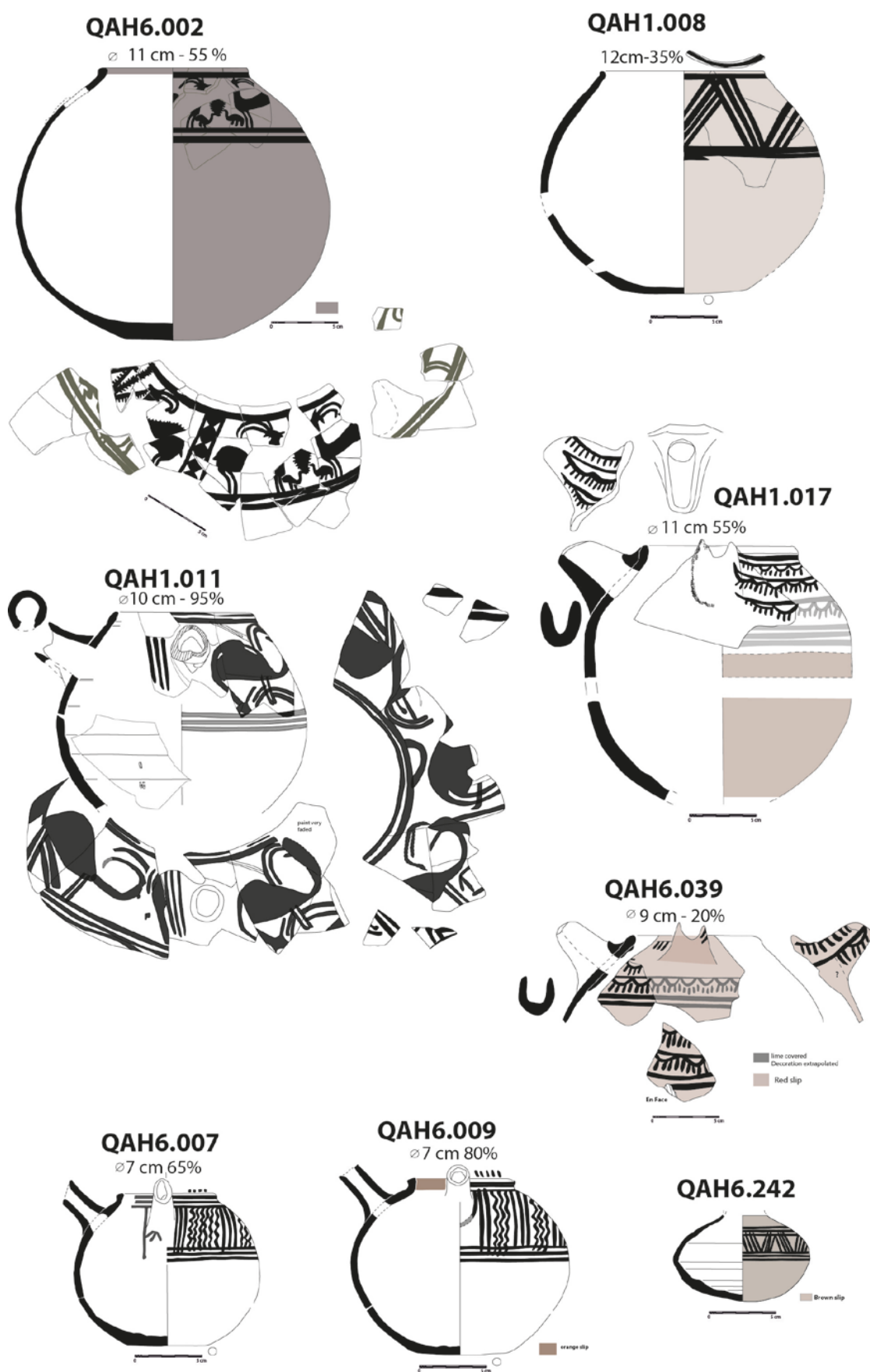


Fig. 6.2: Closed and often spouted jars from Qarn al-Harf, perceived to be early in the sequence.

An important parallel from the Wadi Suq cemeteries in Samad al-Shān shows a similar globular shape, straight rim (slightly pinched) and short almost tubular spout on the rim. It bears an apparent slip and decoration below the rim of hanging triangles filled with nets, which is unique (Yule 2001, Tafel 178: Grab S10932, lower left). The similarities in body shape and other features might suggest common ceramic practices between the area of Wadi Akhdar in Oman, and the vessels found at Qarn al-Harf in the northern Emirates, and likely should be placed at the early stages of the Wadi Suq period.

Diagonal groups of lines in V-shapes

Another decorative motif which is quite rare in Wadi Suq ceramics but seems to have clear antecedents in the Umm an-Nar ceramic industry is that of groups of diagonal lines in V-shapes (*chevrons*) (**Fig. 6.2**; QAH1.008). This pattern of decoration is created by painting diagonal lines in groups, and is one of the most dominant motifs on Black on Red Fine ware necked-jars (Méry 2000, 64, 83: Fig. 49; 84: Fig. 50; 85: Fig. 51). Early Wadi Suq evidence comes from Ra's al Junayz (RJ-2) (Cleuziou and Tosi 2000: 46, Fig. 7.7).

Single or double Wavy lines

This motif is problematic. It is attested in both Sandy Red Ware and fine Black on Red ware (Méry 2000, 138, Fig. 81; 139: Fig. 82; 149: Fig. 89; 150: Fig. 150; Cleuziou *et al.* 2011). It is known from the Wadi Suq, but might be prone to show character reversal (being dominant in use at the end of both periods, see below section on cladistic analysis). Early Wadi Suq vessels seem to show finer painted wavy lines at Qarn al-Harf. The painting of wavy lines is quite universal, and might be connected with a particularly 'rapid' way of decorating (one or double brush, up and down movement while rotating the vessel in hand or on rotary device). However, other motifs, such as vegetal, fishbone, and leaf motifs also occur together with wavy lines (dominant on Sandy Red Ware) (Méry 2000, for instance 88: Fig. 54; 92: Fig. 57).

Significantly, both the motifs of caprids and groups of diagonal lines (*chevrons*) are known from Umm an-Nar ceramics, but might ultimately derive from 3rd millennium BC vessels from south-east Iran (Méry 2000, 100). The chevrons and caprid motifs are well attested in 3rd millennium BC Black on Red painted vessels and their predecessors, so-called 'orange ware' with fugitive slip and black paint, such as

are found at the important site of Konar Sandal (N&S tell) in the Jiroft Valley of south-east Iran (Madjidzadeh and Pittman 2008: Fig. 22). It is these two decorative motifs in particular that we might pinpoint as being ancestral and related to earlier 3rd millennium BC painted vessels.

6.4: Continuity and discontinuity in shapes

In terms of shapes, new vessel types become dominant in the 2nd millennium BC with rarer antecedents in the Umm an-Nar period. The best evidence is provided for the site of Hili in the al-Ain oasis. Beakers and cups, although present, are not particularly numerous in Umm an-Nar period ceramics. These are quite heterogeneous in shape and consistently made in the Red Sandy Ware dating to the later phases of for instance Hili-8 and tomb N at Hili (Méry 2000, 149: Fig. 89.5-10).

However, these beakers often show a single wavy band between two single lines as decoration, in contrast with more elaborate decoration of Wadi Suq beakers and cups (Méry 2000, 149, Fig. 89.5-10). Rarer decoration consists of vertical wavy bands (Cleuziou 1979, 61: Fig.27.5 from phase E at Hili). The latter example comes quite close to early Wadi Suq beakers, such as those attested at Qarn al-Harf. Morphological features might show ancestry, as most of these beakers have (slightly thickened) straight rims. The bases vary from slightly pedestalled to flat. These beakers are made with the aid of coiling and wheel-finishing (Méry *et al.* 2010). As previously stated, it is this local tradition in the use of the wheel in combination with coiling which seems to continue into the early Wadi Suq.

The more numerous single wavy line decoration can thus be distinguished from the double wavy lines on Wadi Suq beakers, but importantly shows that similar types of motifs can re-occur through time (see discussion below). As most of these beakers can be characterised by straight rims, sometimes slightly thickened, and have various bases, being either flat or slightly pedestalled, these technical varieties make choosing a particular outgroup on the basis of Umm an-Nar ancestors slightly more difficult.

The same applies to our second group of vessels, the spouted jar. This type of jar, which was particularly fabricated for pouring liquid, was far from ubiquitous in Umm an-Nar context. As such, it might be the case that a rare spouted vessel found at Hili tomb N is actually an import from the Indus Valley (Méry 2000, 242, Fig. 6).

This parallel might be important, as spouted jars thus seem to be a category familiar to the Indus world, and are also known from 3rd millennium BC Mesopotamia. A rare 3rd millennium BC jar with shoulder spout (partly reconstructed) was found in Grave AS21 at Asimah, however, the excavator suggests a date for the grave in the 3rd or 2nd millennium BC (Vogt 1994 65: Fig.30.1, 66). Moreover, the settlement ceramics from Umm an-Nar island show good examples of domestic ware spouted jars (Frifelt 1995, 58: Fig. 80: period II dated to 2400-2200 BC; 138: Fig. 182; 139: Fig. 183).

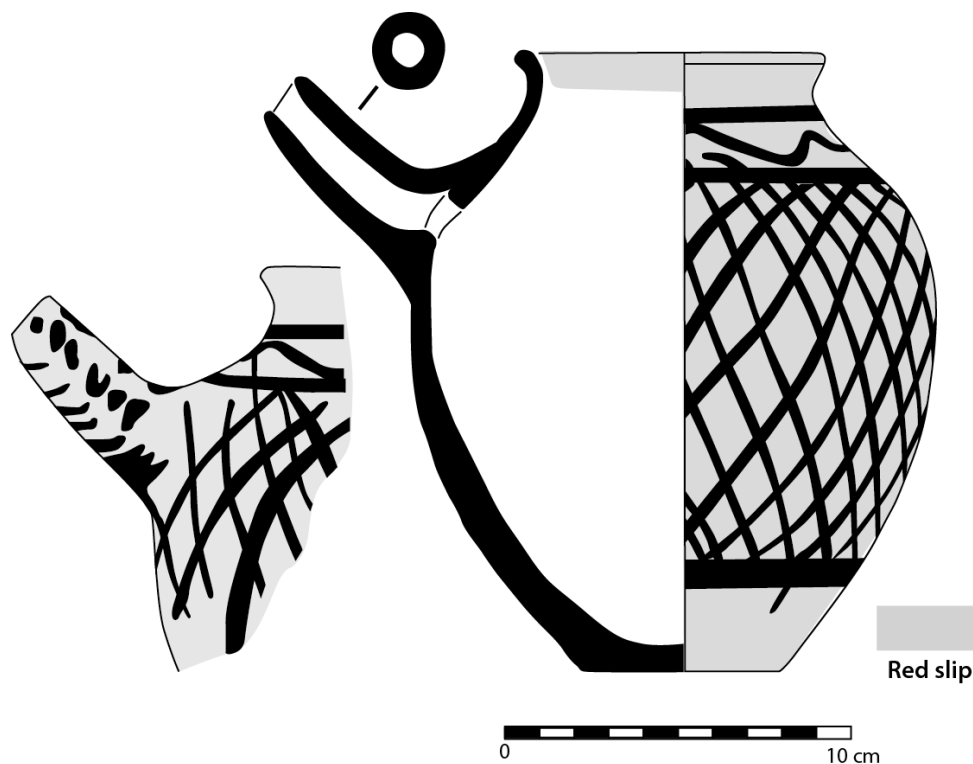


Fig. 6.3: A rare spouted jar from a late UNAR tomb (Hili-N) (re-drawn after: Méry 2000, 2010: Fig. 8.7).

The best example of a spouted vessel, with cylindrical shoulder spout and made in local Sandy Red Ware, comes from the late Umm an-Nar tomb at Hili (tomb N) (al-Tikriti and Méry 2000, 210: Fig. 8.7; Haddu 1989) (**Fig. 6.3**). Significantly, at the Arabian Dilmun related tumuli at Abaiq and at Tarut, spouted jars with tubular shoulder spouts related to Early Dynastic vessels are present and point to the use of this class of vessels in the late 4th millennium BC (Zarins 1989: Fig. 4; Fig. 6). They also form a consistent part of assemblages in south-east Iran, both made in copper alloy and ceramic form (Shahdad, Konar Sandal and Tepe Yahya: Hakemi 1997: e.g.

184, no. 0205; no. 0514; 229, no. 1477; Madjidzadeh and Pittman 2008, 95: fig. 27; Mutin and Lamberg-Karlovsky 2013, 70; 339: fig. 3/14).

6.4.1: Continuity and discontinuity in Fabric: two lines of inheritance: fine wares and Sandy Red Wares

Unfortunately the fabric analysis of Qarn al-Harf is not detailed enough to really comprehend the level of continuity with Umm an-Nar fabrics. For this, a more extensive petrographic analysis of the Qarn al-Harf material, compared to Umm an-Nar fabrics (both Black on Red and Sandy Red ware) would be advisable, in the line of Sophie Méry's earlier work (Méry 2000; 1991b). However, there are perceivable shifts in fabrics and wares related to temper and firing regimes. These changes relate to ceramic practices on the level of raw product procurement and techniques of firing the vessel, both of which are closely related.

6.5: The Umm an-Nar ceramics and agglomerative ancestors

Even though it has become clear that Wadi Suq ceramics have clear antecedents in the local Umm an-Nar ceramic assemblage, it is hard to pinpoint a single outgroup to represent the ancestral state of Umm an-Nar ceramics in our cladistics analysis. It seems better to consider the tradition of ceramic production in the Umm an-Nar period as a conglomerate of ceramic knowledge and practise which was partially transmitted to potters in the 2nd millennium BC, who then re-arranged elements and incorporated them into new vessel categories. It thus seems more feasible to try to find shared characteristics between the Umm an-Nar and Wadi Suq ceramic traditions, and consider these to be ancestral traits inherited from a 3rd millennium BC ceramic tradition. It is actually likely that the ceramic tradition in the Wadi Suq represents a number of different regional traditions. When we come to think of it, this makes perfect sense. Ancestral traits can be present in a number of vessels and a general corpus that was produced at a particular time-span by a group of potters. Taking a single pot to represent this ancestral group would be tricky.

6.5.1: Challenges choosing an outgroup

In the case of Spouted jars at Qarn al-Harf, a quite obvious vessel with traits harking back to Umm an-Nar and south-east Iranian inspired vessels presents itself in the form of QAH6.002. This vessel is thus the first obvious choice as an outgroup in a cladistics analysis of spouted jars of this site.

6.6 Cladistic Analysis

6.6.1: General methodology

A number of separate datasets were devised on the basis of distinct ceramic types from the Wadi Suq tombs at Qarn al-Harf, relating to general types of Wadi Suq ceramics known from other sites. Taxa were devised which either represent groups of vessels with similar morphological and decorative features, ideally based on a shared *chaîne opératoire*, or on individual vessels in more detailed datasets.

Formal vs. quantitative characters

The characters were devised on the basis of visible features, mostly qualitatively defined (formal) and relating to discrete steps within the *chaîne opératoire* (see §3.6.2). Quantitative characters, such as measurements, were not specifically used as the vessels were fragmented though approximate measurements could be taken from the drawings making use of the fragments and because considerable variability was observed within the jars. As such, more formal categories were established to analyse the broader branching patterns. Formal characters relating to general features and based on the forming actions of the potters were seen as more useful at this stage for the analysis. Further quantitative analysis should be incorporated in the future. Characters were either multi-state (more than two options for a character) or binary; defined by presence (1) or absence (0). All datasets were analysed using PAUP* (Swofford 2002). In general a branch and bound search was used which guarantees that the most parsimonious branching pattern is found (see §3.9).

6.6.2: Cladistic analysis of Spouted jars

The first case study concerns groups of jars and spouted jars sharing technical similarities visible in morphological and decorative features. Hence, the taxa form groups of vessels which generally show similar features. The most dominant features within a group were chosen for the analysis. However, in line of what is already known for Wadi Suq ceramic production, there exists considerable variability. This means that within groups, different character states are present, as is very much in line with species having different phenotypic possibilities due to genetic variability, such as the colour of our eyes. It is thus the selective pressure executed on the potter that represents the dominant phenotypes shown for the group.

6.6.3: *Taxa*

File used for analysis: *WS_SJ_GROUPS* (**Appendix 6**).

A number of decisions have been made regarding the construction of taxa and the coding of the characters which will be laid out before going to the results of the present analysis. Sixteen taxa were devised representing the general groups of spouted jars as attested at Qarn al-Harf. In total 60 jars were chosen which comprised enough information to be included in the analysis. Most of these jars had spouts, however some jars for which the spout was not preserved, or were originally without a spout, were included as they seemed to belong to one of the classified groups. Twenty-two characters were chosen based on morphological and decorative traits, and incorporating general information on the fabric.

Shared characters were defined in terms of ceramic fabrication and decoration. However, some of the taxa show a variety of character states. In such instances, the dominant character state was chosen to represent the character state of the taxa. The presence of more than one character state in a taxon is not unlikely, and shows the variation in technical choices a potter had. It is this variation that forms the basis of descent with modification when particular character traits show a selective advantage.

6.6.4: Outgroup

As an outgroup, QAH6.002 was chosen (Group 1). This jar displayed a very fine fabric close to Umm an-Nar fabrics (Fine Black on Red ware), together with a fine red slip and well executed decoration incorporating horned animals (likely a Nubian Ibex), trees and birds. The jar itself is rounded, with a thin inward facing rim. The spout has not been preserved but a hole cut into the wall indicates that the position was likely on the shoulder. As such, the fabric and technical features, together with the ibex motif, are very similar to Umm an-Nar fine wares, yet the globular shape of the vessel and added spout sets it apart as a Wadi Suq example.

6.6.5: Ingroup

Fifteen general groups of jars were defined, mostly with preserved spouts. The groups defining the taxa were composed on the basis of general morphological and decorative features. Whenever possible, the fabric plays a role as well. However, there was considerable variation in the latter.

Group 2a: Consists of six globular jars, mostly with spouts, from the tombs of Qarn al-Harf 1 and Qarn al-Harf 6. The most distinctive feature is a short U-shaped spout on the shoulder, which is not connected to the neck. These jars further have in common: a gritty fabric rich in calcium carbonates (both 13 and 9b have this main character).

This type of fabric is more common in vessels from the tombs of QAH1 and 6. They are predominantly fired under oxidizing conditions. They mostly bear a fugitive red slip. Most have a decorative panel bordered by a single line, though variation exists. The decoration on the upper part of the vessels consists of diagonal lines (QAH1.008); short pending loops and strokes (QAH1.017; QAH6.039), hanging and standing loops (QAH6.084), vertical wavy lines (QAH1.046), and double wavy lines (QAH6.018).

Group 2b: QAH1.011. This is a globular spouted jar with a tubular spout on the neck and a decorative pattern of stylized ibexes. It has a fugitive red slip. The fabric (9b) is fired under neutral to oxidizing conditions.

Group 3: This group consists of three very similar spouted jars from the architecturally early tomb 6. The distinguishing feature of these jars is a fabric distinguished by its buff colour and having limited vegetal temper, and, mostly, wadi pebbles. A fugitive reddish to crème coloured slip is applied to these vessels. The rims are folded and pressed down. These vessels have tubular shoulder spouts. The vessels are wheel made (but probably coiled) and have a well smoothed base when preserved. A black line is painted on the rim. The decoration consists of vertical lines as metopes, with either thin, wavy horizontal or wavy vertical lines between.

Group 4: This group consists of nine vessels. These vessels are globular-shaped, and they have a rim-spout. The dominant rim-type is folded and pinched. The base is either smoothed or shows scrape marks. The majority of vessels bear a red slip. The fabric is dominated by gritty, lime-rich fabrics, though quite a large variation exists. The firing is dominantly oxidizing. Decoration is delineated mostly by three lines. The decorative motifs consist of short hanging loops and short strokes, diagonal chevrons, diagonal chevrons and zigzag lines, human figures and birds (QAH6.006).

Group 5: This group consists of 19 vessels. The group is slightly heterogeneous showing variability in traits. However, some dominant characteristics are a general globular body, a rim-spout, and folded rim. The base is mostly smoothed (dominant character). The fabrics are dominated by vegetal temper, but again show considerable variability. Firing is slightly dominated by reduced cores, or partly reduced firing. The decoration consists of hanging and standing loops between vertical lines, multiple zigzag lines (three or more), zigzag lines and diagonal chevrons, zigzag lines and standing and hanging loops, or half circles with the inner part filled with net patterns.

Group 6: This group is formed by a unique jar. Its decoration stands out in being painted by a thin brush in black on a dark red to brown slip, possibly after firing. It features a triple panel with decoration. The upper panel features a row of birds, often thought to be ostriches. The second panel features human figures in procession, with long sinuous legs, and holding staffs and objects with a bulbous lower part. Moreover, this part of the panel features vegetation in the form of a palm tree, more birds, and a possible boat. This configuration is thus unique and demonstrates good skills by the painter of the jar. Unfortunately, this jar was heavily fragmented as well. The fact that the jar was greatly appreciated for its decoration might be obvious from the repair holes drilled in the spout which broke off and was repaired some time before being interred in the tomb. As such it attests to older vessels being interred in the tombs as well.

Group 7a: These are vessels which show common features in being globular. They have a folded pinched rim. Both vessels have a rim-spout. The base on the best example is string-cut and shows scrape marks. The decoration of both vessels consists of either two or three zigzag chevrons painted between double lines.

Group 7b: Group 7b consists of a squat vessel with a rim-spout and smoothed base. The rim is everted. It features a red slip. The fabric is dominated by vegetal temper and the firing was partly reduced (core). The decoration consists of three zigzag chevrons between double delineating lines.

Group 8a: This group consists of three vessels. The jars are globular and show a rim-spout. The decoration consists of thick horizontal wavy lines between single lines.

Group 8b: consists of a single vessel at Qarn al-Harf. It could be included into group 8 but shows a different squat shape. It features a rim-spout. It has clear internal rilling being made on the wheel with a scraped base. The decoration consists of thick horizontal wavy lines between single lines.

Group 10: Consists of three vessels (QAH5.010; QAH5.011; QAH5.013). The main characteristics are large globular bodies. They were probably wheel-made with the use of coiling. The rims are folded and hammer-shaped. The spouts are attached to the shoulder and trumpeted. The bodies show regular rilling which might be indicative of coils. The decoration consists of pendant triangles between single or double lines of decoration.

Group 11: Consists of two vessels (QAH2.014; QAH2A:002). This group is characterized by being wheel-made (finished) with roughly worked bases showing traces of scraping and initial string-cutting. The rim is folded and thickened. The spout is placed on the shoulder and trumpeted. The fabric is rich in vegetal temper and the vessels show a reduced core (sandwich firing). Decoration consists of wavy vertical and horizontal lines.

Group 12: This group is formed by a unique vessel (QAH5.024). It is globular in shape with a reddish slip. The spout is pinched and placed on the shoulder (anachronistic). The base is smoothed but shows traces of cutting. The fabric is characterized by vegetal temper. Decoration consists of three horizontal bands under rim, and two horizontal bands on the shoulder. The panels are filled with standing and pendant double loops and two horizontal wavy lines.

Group 13: This group (QAH5.027; QAH6.011) is characterized by two globular jars with shoulder spouts with a trumpeted shape. The vessels feature a folded hammer rim. The jars are made on the wheel and show signs of string-cut bases. The fabric is characterized by vegetal tempering. They stand out because of an absence of painted decoration.

6.6.6: Characters

Formal vs. quantitative characters

As mentioned above the character traits chosen for this case study are based on formal categories. This choice was made due to several reasons. Firstly, vessels were

fragmentary and good measurements could not always be taken. Rim-diameters were measured for the vessels and helped to establish categories of shape, together with the preserved outline of the body of the vessels. However rim diameters are prone to standardization on the basis of estimates made with a diameter chart, thus not reflecting the more accurate variety in diameters. Approximate measurements can be taken of vessels of which the full profile could be reconstructed (and drawn) but often they remain still fragmentary in nature.

In general, shape categories can be shown, but individually the vessel morphologies show considerable minor variation. To make it possible to use the widest range of data from the ceramic vessels at Qarn al-Harf and compare them to other locations, more simple formal descriptions are used for now. However, with more time and more complete (reconstructed) vessels, better quantitative measurements should be taken. Nevertheless, this approach makes it possible to compare the cladistics results with vessels from other tomb assemblages, showing similar general features.

Thus characters were selected predominantly on the basis of techniques used in forming and decorating the vessels, in other words relating to the *chaîne opératoire*. Morphological characters were taken into account as representing differential actions by potters, such as the general shape of the vessel, different ways of folding the rim, and the way the spout was made and the position it was added onto the body. Moreover, characters relating to the surface treatment (slip) and decorative patterns were chosen; and relate to the choice a potter had in using delineating lines, and the range of motifs painted on the vessels. In this way, 22 characters were chosen for the analysis (**Appendix 6**).

These represent both multivariate characters and bivariate characters (presence/absence). The characters relating to decorative patterns were chosen to be bivariate, as a certain character can contain more than one decorative pattern. As such it was deemed more suitable to code them in this way, instead of devising multi-character states that would lead to considerable overlap.

6.6.7: Results

The cladistics analysis yielded nine equally parsimonious trees with a length of 66. The results are summarized in **Table 6.2** and **Fig. 6.4**. Of the 22 initially coded, two were parsimony uninformative. The retention index of 0.5 shows that there is considerable homoplasy in the data; meaning character changes which are not explained by descent from a common ancestor (**see §3.6**). However, a RI of 0.5 is not considered too low for a cladogram to reflect a good phylogenetic signal (Tehrani and Collard 2009b).

Taxa	16
Characters	22
PI Characters	20
# Trees	9
Tree length	66
CI	0.5455
CI excl. uninform. Char	0.5313
HI	0.4545
HI excl. uninform. Char	0.4688
RI	0.5000
Rescaled CI	0.2727

Table 6.2: Basic results for spouted jars cladogram generated by PAUP 4*

6.6.8: Bootstrap analysis

A bootstrap analysis (1000 and 10,000 repetitions) shows a fully collapsed tree, showing no support for any particular branch. The reconstructed tree is thus not very robust. This might be suggested to be due to considerable homoplasy in the data.

6.6.9: The Branching pattern

The generated trees show an interesting branching which cannot directly be taken to represent a strict chronological pattern, but does relate to changes in ceramic production over time.

Group 3, chiefly characterised by its cylindrical shoulder spouts, is suggested to be an early branch, forming a clade with 2b and 2 to the exclusion of the following groups. The branching pattern would suggest these jars to represent earlier shapes in the evolution of spouted jars, at least at the site. This is consistent with their context in tomb 6 showing Umm an-Nar ancestral architectural features. The branching pattern subsequently seems to follow a pattern where spouted jars develop a rim-spout, have red slipped surfaces, often with well smoothed bases, and decoration consisting of finely painted chevrons and zigzag lines, hanging and standing loops. These jars often feature two panels of decoration (Group 4).

Group 7b shows a mutation in the shape of the vessel, being squat. However, it still shared many characters with group 4, such as the fine red paint and type of decoration. A separate clade is formed by group 5 and 6, showing a recent common ancestor. Group 6, with human figures and birds painted is in itself unique, but seems to be most closely related to group 5, sharing features such as slipped surfaces and rim-spouts, and decoration often applied with a fine brush.

The following clades seem to show a development in base-type, often being left unsmoothed and showing scrape marks. Although this feature is present in earlier clades, it becomes dominant with the branching off of groups 7 to 13.

Group 7 and 12 form a separate clade. This clade is rather interesting in terms of chronology. On the basis of shoulder spout, group 12 could be suggested to be later in the evolutionary sequence, but the presence of slip and decoration would suggest it is closer to groups such as 4 and 5, suggested to be earlier in the sequence. In the reconstructed tree, this group forms a clade with group 7. This jar can be interpreted in two ways: the spout is either an early attestation of a shoulder spout, or the decoration and slip are quite ancestral and show character reversal. Group 10 and 13 form a separate clade at the end of the cladogram. The jars from these groups share common features in having trumpeted shoulder spouts.

6.7: Discussion

A Retention Index (RI) of 0.50 is generally acceptable for a branching pattern (Collard *et al.* 2006b). However, more recent analysis sets a limit for the RI around 0.6 to be interpreted as giving a good phylogenetic signal (see Nunn *et al.* 2010). It seems that the RI of 0.5 thus shows considerable homoplasy, likely due to processes

of horizontal transmission. This is also visible in a homoplasy index of 0.55 (0.53 excluding parsimony uninformative characters). Similarly, the Consistency Index excluding uninformative characters at 0.53 is rather low. A bootstrap analysis yields no particular support for any of the branches, and shows the reconstructed tree not to be particularly robust. Nevertheless, the pattern reflected in the majority consensus tree showing nodes present in 50% or more of the equally parsimonious trees does fit a general pattern of expectation for the evolution of these jars considering their placement in the tombs at Qarn al-Harf, and related to the developments already suggested by Christian Velde (2003: 104). This pattern is reflected in similar developments which are independently attested for the beakers and cups (see below).

Relation to production process	CHAR	Short description	CI	RI
Morphology	1	Body shape	0.5	0
	2	Spout	0.67	0.5
	3	Rim	0.83	0.75
	4	Base	0.5	0.8
Surface treat.	5	Slip/Ware	0.67	0.83
Clay preparation	6	Fabric	0.75	0.67
Firing	7	Firing	0.5	0.6
Decoration	8	Lines on rim	0.33	0.6
	9	Delineating lines panels	0.67	0.5
	10	Small loops (short strokes)	0	0
	11	Hanging and standing loops	0.33	0
	12	Zigzag chevrons >3	0.33	0
	13	Zigzag chevrons 3 or less	0.25	0.25
	14	Horizontal wavy bands	0.33	0.6
	15	Horizontal lines	1	0*
	16	Vertical wavy lines, or horizontal wavy lines between straight lines	0.5	0
	17	Adjoining triangles net-filled	0.5	0
	18	Lines with short cross strokes/barbed wire	1	0*
	19	Diagonal group of chevrons	0.33	0.33
	20	Birds/ostriches	0.33	0
	21	Ibex	1	1
	22	Human figures	0.5	0

Table 6.3: showing the individual CI and RI for the characters (CHAR), calculated with Mesquite (Maddison and Maddison 2011).

6.7.1: The CI and RI for individual characters

With the cladistic analysis showing evidence for both descent with modification from a common ancestor, and other processes likely related to more vertical transmission, it

might be instructive to examine how different processes could have affected the individual characters used within the analysis, relating to different steps in the production sequence.

6.7.2: Morphological characters vs. decorative motifs

As discussed in chapter 2, the visibility of characters and ease of copying might play a role, thus yielding decorative characters a higher chance for horizontal transmission. To test this assumption, we can measure the RI for the set of characters representing the forming technique, clay preparation, surface treatment and firing (characters 1-7 in the dataset), versus the characters coded for the decorative motifs (8-22). Including only the characters related to forming and firing the vessel, this gives a RI of 0.57. A cladistic analysis using just the decorative traits (8-22) yields a RI of 0.281. The RI of the decorative traits is far lower, and suggests considerable homoplasy, likely due to horizontal transmission.

The CI and RI can be informative to study the individual characters fit to the branching pattern. In other words, an especially high RI for characters could be indicative of vertical transmission, and could be singled out as useful in observing descent with modification, both in a geographical and chronological sense.

In terms of morphology the body shape shows a RI of 0, meaning it is not consistent with the branching pattern of the tree. This might be a consequence of this morphological feature not being accurate enough in terms of measurements. However, it would also indicate that the general shape of these vessels is quite variable. More detailed analysis of the morphological features with a well suited set of vessels would be necessary to establish this. Other morphological features show more promise. The spout has a RI of 0.5. This means it is rather prone to homoplasy. However, there is a phylogenetic signal here for roughly half of the vessel groups. This is interesting in itself. It might be suggested that the type of spout shows descent with modification, but that this pattern might be disturbed by homoplasies relating to character reversal and horizontal transmission such as borrowing. As previously discussed (chapter 3), the high visibility of the spout and ease of applying the spout in different ways would suggest both cases could be true. The rim is rather surprisingly consistent with the branching pattern (CI 0.83 and RI 0.75), showing relatively little homoplasy. This would suggest that the rims are prone to vertical transmission. This in itself is an

important conclusion. It suggests that the way of finishing a rim is likely to be transmitted within a locally learned *chaîne opératoire*. Previous studies have not focussed heavily on rim-types, suggesting they would not be very good for typologies (Velde 2003; Velde *forthcoming*). This result would suggest the opposite, and argue for more detailed study of finishing rims. The high RI might suggest it is prone to local patterns of descent with modification related to groups of potters. The way of finishing the base seems particularly prone to vertical transmission (RI of 0.8). This would support the hypothesis that the way of finishing the base, relating to the way the wheel is used, is based on technical actions which are likely transmitted vertically within a group of potters. This is consistent with the idea that the use of the wheel and associated signs of such use are related to practice and knowledge which is learned from other potters within the same group and seem to point to a core set of technical actions which show high fidelity in transmission.

6.7.3: Character reversal of the spouts

The type of spout shows reasonably good fit to the branching pattern of the reconstructed tree, however, considerable homoplasy is suggested by the RI of 0.5 (CI of 0.65 and RI of 0.5; around half of the character changes are explained by homoplasy). When examining the character changes for the type of spout using Mesquite there is considerable character reversal, or horizontal transmission between the separate clades. Both of these developments would be fairly easy to explain due to the high visibility of the spout on the vessel, and the relative ease for a potter to construct one of the spouts. Moreover, the evolutionary pattern suggests that spouts were initially placed on the shoulder (either cylindrical or short tubular). From a functional point of view, the exact shape of the spout does not have major consequences for its functioning, making it a fairly flexible element of a pot to change. This is in line with the Umm an-Nar spouted jar discussed above, also showing a cylindrical spout. Subsequently, the spout was positioned just beneath the rim and had a short tubular shape. A further development sees the spout being placed underneath the rim again, and finally being placed on the shoulder, having a distinct trumpet shape. There thus seems to be a clear character reversal in terms of the *position* of the spout. It can be suggested that the type of spout is chronologically significant, but that other characters should ideally be taken into account.

6.7.3: Surface treatment

The presence or absence of slip seems to relate well to an evolutionary branching pattern (CI 0.67, RI 0.83). Earlier vessel types seem to show the application of fugitive red slip. Red slip is applied to vessels at a relatively early stage of the Wadi Suq as attested at Qarn al-Harf, but seems to be less common in later branches. The lack of red firing slip might be partly explained by the changing firing regime, where less oxidizing firing resulted in a more neutral surface colour upon which black decoration was applied.

6.7.4: Firing

The way of firing the vessels, either predominantly oxidizing, neutral or with a reduced core, seems to be related to patterns of descent with modification suggesting the change in firing regimes shows a reasonable vertical signal (RI is 0.6). However, the way of firing is flexible and can generally differ based on rather *ad hoc* circumstances. This would fit an idea that ceramic production in the Wadi Suq is less specialised in terms of skill involved (Carter 1997a, 86). However, a general shift towards reduced cores, in combination with fabrics more dense in vegetal temper has been observed (Méry 1991b; Carter 1997a, 212-213; Velde *forthcoming*), and is supported by the present analysis for these spouted jars. This choice has been related to the ameliorating environmental conditions in the Late Bronze Age and early Iron Age I, suggesting a decision to spare fuel (Carter 1997a, 224). However, considering the calcareous nature of the fabric, with dominant limestone inclusions, it can also be suggested that this decision is based on a concern to counter lime-spalling (Rice 2005, 98; see further in discussion). This idea was already suggested by Méry in reference to the calcareous clay (fabric and non-plastics) at Shimal, as discussed in the section on Wadi Suq fabrics (Méry 2000, 270). As suggested before in chapter 5, a shift in the location of pottery production towards the northern Emirates might coincide with the use of lime rich clays (and richly present iron oxides) typical of the geology of the northern part of the Hajjar mountains (Ruʿus al-Jibal). This could explain why potters had to adjust the firing regime to counter unwanted effects of ‘lime-spalling’ (§5.9.4).

6.7.5: Fabric/ware

When using general fabric groups based on more detailed fabrics in the field, it can be suggested that a shift in fabric is visible and shows a relatively consistent branching

pattern (CI of 0.75, RI of 0.67). Nevertheless, there seems some reticulation where fabrics are used across the spectrum of vessels. This fits the model that the fabrics were locally derived, but show considerable variability for individual vessels (Méry 1991b, 253; Méry 2000, 270). Nevertheless, the general choice of fabric thus seems to be regulated by vertical transmission.

6.7.6: Decoration

The type of lines painted on the rim seem to show good support for a branching pattern (RI 0.6). However, it must be kept in mind that this character varies within the group. Moreover, a minority of vessels have a single painted line on the rim, not represented in the matrix. Nevertheless, this would suggest this practice is socially inherited and indicative of vertical transmission. It is interesting that similar ways of decorating the rim are observed at nearby Shimal (Velde *forthcoming*). It would again be a strong suggestion that the community of potters responsible for the vessels at both these cemeteries are quite closely linked in terms of practice. Moreover, it might suggest that the rim decoration is somehow linked to the rim type itself, and less ‘flexible’ than other aspects of ceramic decoration.

Other decorative motifs show relatively low RI, suggesting that decoration could be easily transmitted between groups of potters and thus relating to more vertical processes within the evolution of these ceramic vessels. However, horizontal wavy bands seem quite consistent with the branching pattern. Most significant is the motif of the ibex, singled out before as a characteristic that might be inherited from Umm an-Nar decorative styles. It shows a CI and RI of 1, suggesting a perfect fit with the branching pattern. As such, it features in the outgroup (QAH6.002) and group 2b, but is absent from other groups which branch off later. It thus seems to fit the hypothesis that this motif is particularly related to the 3rd millennium BC and early Wadi Suq, but does not feature dominantly as a painted motif on later vessels.

Nevertheless, the cladistics analysis does support an evolution in ceramic designs. However, as noted in chapter 3, the evolution of decoration might be related to more pronounced horizontal transmission, as it was a highly visible and easily replicated feature. We will go into the implications of the results in more detail in the general discussion

6.7.7: Setting ancestral traits to reconstruct the tree

It is possible to choose character traits which are deemed as ancestral on the basis of the existing hypothesis. This was done for the dataset assuming the ancestral spout type to be a cylindrical shoulder spout (like the Umm an-Nar vessel from Hili Tomb N, see above) and the decorative patterns of the ibex and diagonal chevrons as ancestral (coded in PAUP as: *ancstates* *ancestors* = 4:2, 1:19, 1:21).

The analysis was carried out with the intention of seeing whether cladistic analysis would yield a drastically different tree, or support the tree as suggested on the basis of a single vessel representing the ancestor (QAH6.002). Importantly, the results were the same as when using this single vessel as an outgroup. This might perhaps be taken as a support for the assumption that this vessel is indeed related to Umm an-Nar ancestry (based on the ancestral characters it shows). Moreover, it would suggest that the hypothesis that these traits are indeed ancestral deserves some merit.

6.8: Cladistic analysis of Cups/Beakers

As mentioned, the choice of an outgroup is not straightforward for the category of beakers and cups. There are a limited number of examples of such beakers known from late Umm an-Nar contexts, but these show different technical characteristics and cannot readily be taken as outgroups for the analysis (Méry 2000; al-Tikriti and Méry 2000). Moreover, there are apparent issues with a quite obvious character reversal (see below), as for instance pedestaled foots and string-cut marks are associated with late Umm an-Nar vessels and perhaps related to technical developments in the Indus Valley (Cleuziou 1979, 61: Fig. 5-6 from phase E at Hili; Méry 2000, 54: Fig. 26; Potts 1993a, 120; Weisgerber 1981). However, the same features are seen as typical for the late Wadi Suq and Late Bronze Age, and are sometimes connected with Mesopotamian influenced shapes of beakers and goblets which become popular in Dilmun related contexts as well (Armstrong and Gasche 2014, for example: Plate 97: Type 210 B2; Magee 2014, 190; Velde 2003). In both cases the morphological features can be partly, if not largely, explained by the vessels being produced on a wheel and removed by cutting away the vessel with a string, the pedestaled foot left in place rather than reworked by shaving and smoothing. Hence, the technical choices might have overlapped with vessel types known from other regions (such as Mesopotamian influenced beakers). The similarity might thus be a consequence of

convergence: the association with Mesopotamian (and Dilmun) style beakers welcomed by the potters and users of the beakers. Most significantly, these technical features relate to particular choices of potters fluctuating through time, and cannot be taken as ready chronological indicators. However, the above described *chaîne opératoire* as attested at the end of the Umm an-Nar period at Hili in the local ceramic tradition leaves us with detailed information on the production of late Umm an-Nar vessels, including small beakers, which can at least indicate some features which are likely to represent Umm an-Nar ancestry.

Yet significantly, at Qarn al-Harf, vessels with a more gritty fabric (9a-b) are known mostly from the architecturally earliest tombs of QAH1 and QAH6, of which QAH6 is clearly early in the architectural tradition. These beakers and cups show a relatively thick wall, wide profiles and straight rims. Moreover, a clear decorative pattern can be recognized as descendent from the Umm an-Nar period both in closed and open vessels, consisting of groups of vertical chevrons (see §6.3.3), also recognized as ancestral in spouted jars. This group of beakers was thus taken as represent the outgroup in order to root the tree.

6.8.1: General groups of beakers and cups

Dataset: *WS_Beakers_Gengroup_6* (**Appendix 7**).

Methodology

Taxa

Six main taxa were devised representing 121 categorised beakers and cups from the tombs at Qarn al-Harf. These were chosen because they provided information relevant to a large part of the technical traits used as characters in the analysis. The taxa were defined by grouping the vessels into fairly homogenous groups in terms of morphology, technical choices displayed in their manufacture, and decorative patterns and motifs. Yet importantly, variation exists within these groups, such as the application of slip, firing, etc., which inhibited the possibility of devising multi-state characters for individual technical features of each group, as multiple character states are present within a single taxa. Instead I chose to code the individual character states by presence and absence, as multiple character states could be present in a single group (for instance multiple ways to finish the rim). An advantage of this approach is

to increase the number of characters to analyse making the result more robust. Moreover, it has the potential to show the gradual changes in mutations between the groups.

This variability represents multiple options for the group of potters responsible for the vessels deposited in the tombs. They thus likely reflect the variability in choices at the level of groups of potters, and consistency was likely higher for individual potters, but this level of detail is beyond the reach of the present dataset.

The outgroup

The outgroup consists of three beakers QAH1.067, QAH1.075 and QAH6.033. These vessels were chosen to represent a communal outgroup.

The choice for these three vessels is based on their fabric, which was gritty, with pebbles, quartz sand and limited vegetal temper (fabric 9 related); and their morphology, being rather thick walled and relatively wide in shape, likely produced with coiling and aid of the wheel, and the application of decorative patterns which can be seen as ancestral, that is: thin wavy lines and particularly diagonal chevrons. In terms of context, the vessels came from the tombs of QAH 1 and QAH6, which fits the assumption of their earlier date.

Nevertheless, care must be taken not to fall into circular reasoning and the data-set is designed to show if ‘descent with modification’ is a valid model for the beaker and cups from these tombs, and how this model would fit with the archaeological data. The groups are divided by general shape.

Group 1

This group consists of five beakers and cups. They are made in a variety of fabrics, mostly fabric 9 and sandy fabrics 3 and 4 characterized by limestone temper. The unifying factors are a wide profile with straight walls. The rims are straight. The base of these vessels is smoothed. Slip, mostly in a red hue, is applied to the outside of the vessel. The decoration varies and consists of groups of vertical lines (defining the decorated area) with vertical wavy lines or a single wavy line between, and a rarer version with vegetal motif and unidentified motif (QAH1.111).

Group 2

This group consists of 42 beakers and cups, which have a number of features in common. The vessels are wheel-made, but show signs of coiling as well, suggesting that they are coil made and wheel finished. The rim is relatively thin with straight walls.

Group 3

This group consists of sixteen beakers and cups. These beakers and cups have in common that they are wheel-made but coil built, often showing good signs of pressed down coils with sharp edges on the inside of the vessel. The shape is more oval than group 2, showing a rounded base and slightly sinuous or inward facing neck.

Group 4

This group consists of 36 beakers and cups. These beakers and cups have in common that they are wheel-made, and showing signs of being fully formed on the wheel (thrown). The body of the vessel shows straight walls and the rims are often everted. The bases are most frequently left unfinished and show string-cut marks.

Group 5

This group consists of nineteen beakers and cups. These beakers and cups have in common that they are wheel-made, and show signs of being thrown on the wheel. The body of the vessel has straight but inward facing walls with everted rims. The bases are most frequently left unfinished and show string-cut marks.

Characters

Because of the continuity of the data, multi-state characters were chosen with presence or absence, except for the shape of the vessel. This leads to 41 character states in total (see **appendix 7**: character state list). A similar approach was successfully used in a recent cladistic study involving Egyptian ovoid storage jars (Hood and Valentine 2012).

Results of the cladistic analysis

A single tree was generated with a length of 45, a Consistency Index of 0.89, and a retention index of 0.67 (**Table 6.4**)

# Trees	1
Tree length	45
CI	0.8889
CI excl. uninform. Char	0.7368
HI	0.1111
HI excl. uninform. Char	0.2632
RI	0.6667
Rescaled CI	0.5926

Table 6.4: showing the general information generated by cladistic analysis in PAUP* (Swafford 1998).

A concern can be raised over the number of parsimonious uninformative characters (23 of the 41 characters: 56.1%). However, this seems not to be uncommon in phylogenetic datasets, if compared to the data presented by Collard and Tehrani (2006: 176: Table 3). Moreover, the parsimoniously uninformative characters are still relevant from a phenotypical point of view, and form part of the characteristics of groups of vessels on which typologies are based.

The CI is high (0.89), slightly lower when excluding the parsimony uninformative characters (0.73). The RI of 0.67 shows dominance of homology, and the results are perfectly acceptable compared to the RI published for other biological and cultural data (Collard 2006: 176, Table 3). Moreover, recent studies have shown that lower RI do not have to be directly related to processes of blending (homoplasies) but can be related to other factors such as the frequencies of fission and the rate of evolution (Crema *et al.* 2013; Nunn *et al.* 2010).

A bootstrap analysis shows good support for the branching pattern with 89% of the 10,000 replications showing support for the clade including groups 2, 3, 4 and 5, 79% showing support for the clade including group 2 and 3, and 94% showing support for the clade including group 4 and 5. This particular tree offers no resolve considering the timing of these branching events, suggesting that the clade of group 4 and 5 branched off at a later stage than 3 and 4.

Bremer support offers another quantitative support for the branching pattern. The support might be defined as the “extra length need in the consensus of near-most-

parsimonious trees” (Bremer 1994, 295). In other words, it shows the robustness of the clades still present in trees which are only slightly less parsimonious, with an increasing number of character changes needed (resulting in a slightly ‘longer’ tree), and thus still show high degrees of homology. The Bremer analysis suggests decay indexes of two steps for the clade of group 2 and 3, and a Bremer decay index of four steps for groups 4 and 5. This indicates that the clade with group 4 and 5 is particularly robust.

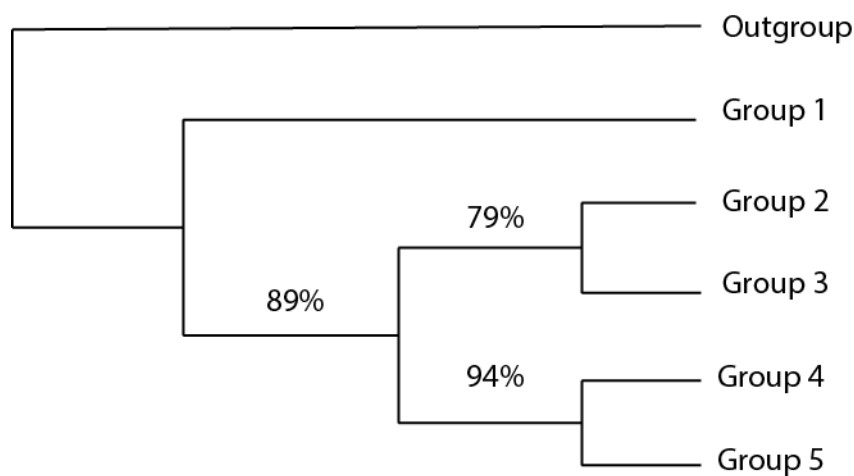


Fig. 6.5: Cladogram with bootstrap support (10,000 repetitions), generated by PAUP*

The branching pattern would suggest that the outgroup and Group 1 form a clade to the exclusion of Groups 2-5. A further branching event suggests Group 2 and 3 form a clade to the exclusion of Groups 4 and 5, which form a separate clade. The individual CI and RI might show interesting patterns regarding the fit of individual characters with the general branching pattern.

6.8.2: The CI and RI for individual characters

How can we interpret these data? The high CI and RI show they are very consistent with the branching pattern and do not show homoplasy, thus do not appear in taxa on separated clades. However, the transitions must be seen as gradual, thus suggesting a gradual evolution in techniques.

General relation to production sequence	CHAR		Short description	CI	RI
<i>Morphology</i>	1	Shape	General shape	1	0
	2	Rim	Straight: >160-180°	1	0
	3		Slightly everted: 160-140°	1	1
	4		Everted: <140-120°	1	1
	5	Base	Smoothed	1	0
	6		Shaved	0.5	0.0
	7		String-cut	1	1
<i>Surface treatment</i>	8	Slip	YES	0	0
	9		NO	1	0
<i>Firing</i>	10	Firing	OX	0	0
	11		NEU	0	0
	12		SW	1	1
	13		RED	0.5	0.5
<i>Decoration</i>	14	Delineating lines	3 or >	1	0
	15		2	0	0
	16		1	1	1
	17		0	1	1
	18	Thin wavy horizontal lines		1	0
	19	diagonal chevrons		1	0
	20	vertical lines with vertical wavy lines		1	0
	21	vertical lines with single wavy line		1	0
	22	Vertical thick lines		1	0
	23	hanging loops and short strokes		1	0
	24	vertical lines with hanging and standing loops		0.5	0.0
	25	vertical lines with vertical loops along lines		1	0
	26	horizontal lines with loops attached		1	0
	27	4-5 zigzag chevrons		1	0
	28	3 zigzag chevrons		0.5	0.0
	29	2 zigzag chevrons		1	0
	30	Thin attached triangles: 'butterfly'		1	0
	31	empty space between vertical delineation		1	0
	32	vertical lines		1	0
	33	wavy vertical lines		1	1

	34	Thick wavy lines	1	0
	35	double dots	1	0
	36	vegetal motif	1	1
	37	net-pattern	1	1
	38	attached triangles filled with net-pattern	1	0
	39	groups of vertical and diagonal lines	0.5	0.0
	40	Group of vertical lines	1	0
	41	Rilling	1	0

Table 6.5: Individual characters (CHAR) and CI/RI for these characters used in the analysis, generated with mesquite (Maddison and Maddison 2011).

6.8.3: Morphology

In terms of morphological characters, the shape has a high CI (of 1) but is not very consistent in terms of the RI. However, this might be a consequence of the groups being quite large, thus representing more than one shape. The decision of the potters to fold the rim outwards slightly, or fold it so that it appears everted is very parsimony informative. Slightly everted rims are associated with Groups 2, 3, 4 and 5. Whereas everted rims are associated with Groups 4 and 5. In terms of the finishing of the base, the presence of string-cut marks is highly informative (RI of 1) and features on the clade of Group 4 and 5, setting this group apart. In technical terms it can be suggested that the clade of Groups 4 and 5 is particularly strongly connected to using the full potential of the wheel, not only to thin pre-coiled vessels (as in Groups 1, 2, and particularly 3) but to use the wheel to form the vessels directly, with wheel-throwing possible for Groups 4 and 5. Nevertheless, the use of coils still seems in vogue. We will get into the implications of this result in the general discussion.

6.8.4: Surface treatment

In terms of surface treatment, the presence or absence of slip seems to show considerable homoplasy (a CI and RI of 0), and is thus not very consistent with the branching pattern. However, considering the rough percentage of slipped vessels might be interesting, as it would show a decrease in slipped vessels. This will become clearer in the following case study with a smaller subset of taxa, where the presence or absence of slip is highly relevant.

6.8.5: Firing

The general firing atmosphere attested for the groups, though variable within these groups, shows particularly good support for the character change associated with reduced cores. This falls within the expected pattern, as this technical choice is most clearly associated with Groups 2, 3, 4 and 5, and can be suggested to form a local adaptive strategy to the presence of calcium-rich clay and inclusions, and the associated prevention of lime-spalling. In previous studies it has been associated with environmental changes as well, with aridification leading to a reduction in fire-wood (Carter 1997a, 224). However, this causal connection is not completely clear, and we do not know exactly what was used as fuel. For instance, animal dung would have been an alternative option to wood. Considering the local ceramic production and calcium rich clays (see above discussion on Wadi Suq ceramics), I suggest that this strategy was particularly associated with the firing properties of the clay; where sintering and lime-spalling is observable in the ceramics at Qarn al-Harf and Shimal (Méry 2000, 270). This effect was unwanted and selected against by the potters because it obscured painted motifs. The resulting change in firing regime for the vessels involved a shorter period of firing or lower temperatures leading to the incomplete oxidization of the cores of the vessels.

6.8.6: Decoration

The features that seem to stand out most are wavy vertical lines, vegetal motifs, and net-patterns with a RI of 1. A problem with the RI of the decorative motifs is that a number of them are parsimony uninformative, thus yielding a default RI of 0. The overall result would suggest that the branches representing the earlier groups show more variability. This could be due to the way that the groups are constructed, actually representing distinct sub-groups. Or it could be due to a decrease in variability in manufacture for the beakers and cups. This can be further explored in the second case study involving beakers and cups.

6.9: Specific types of beakers and cups

Cladistic file: WS_beakers_22taxa (**Appendix 8**).

6.9.1: Taxa

For a more detailed study of the evolution of beakers and cups, twenty-two beaker groups were chosen from Qarn al-Harf that mostly have counterparts at Shimal tombs or other sites as well (save from some unique cups). These beakers and cups relate to the more general groups used above, but have been divided into detailed groups on the basis of more complete knowledge of their fabrication. No distinction is made at this point in rim-diameter, although a clear division can be seen with cups with rim diameters below 10 cm, and beakers with rim diameters above 10 cm. However, from a technical stance, both cups and beakers show very similar developments in terms of the *chaîne opératoire*. It is at this level that we want to analyse descent with modification. The twenty-two groups were based on types devised when studying the ceramics from Qarn al-Harf. The typology was based on general vessel shape, but these appear in groups of vessels with different rim diameters. Most diagnostic for the types are the visible technical features relating to the *chaîne opératoire*, such as the general body shape, rim-shape, treatment of the base, the surface treatment (slipped or un-slipped) and the decorative pattern.

6.9.2: Outgroup

As an outgroup, **Type 1.2**, represented by QAH1.067, was taken. The initial cladistics analysis yielded good results for this vessel as an outgroup, in combination with Type 1.1. Moreover, it features a type of painted decoration of diagonal chevrons which has clear links to 3rd millennium BC Umm an-Nar ancestry and features as such in the cladistics analysis of spouted jars as well.

6.9.3: The Ingroup

The taxa are based on types of beakers and cups found in the tombs at Qarn al-Harf and associated with other Wadi Suq tombs.

Type 1.1: Mostly feature straight sides and a straight rim. They are smoothed and often bear a reddish slip. The decoration consists of vertical wavy bands, often more than four. The wavy bands have short loops, distinguishing them from the later decoration of two wavy bands.

Type 1.3: This type of beaker has a rim diameter – of around 10 cm - with straight to slightly inclining walls and rim. The beakers are smoothed and slipped in a light brown or reddish colour. The decoration consists of vertical lines and groups of vertical wavy lines.

Type 1.4: These are beakers with straight walls and rims, bearing a red slip. The decoration consists of at least three panels filled with small pendant loops and short strokes beneath.

Type 1.5: Beakers with motif 2, consisting of vertical lines and hanging and standing double or triple loops, are a well-attested type in the Wadi Suq period and seem to be one of the hallmark decorations. The decoration is paralleled both on jars and beakers, dominating on beakers. Significantly, Qarn al-Harf now shows good evidence of cups with this motif, suggesting that it does not only feature on larger open vessels, but also on cups (see below).

Type 1.8: This unique cup has straight walls and rim with a smoothed base. The decoration is close to motif 2, but consists of two vertical lines painted mid-body, with double hanging and standing loops on both sides. Small loops are painted from the rim. No exact parallels are attested. It seems an early variation of the painted loops motif.

Type 1.10: Two cups show straight walls and rims, with well smoothed and slipped body. The decoration is unique and seems to be a vertical oriented variation of the more common motif 2 with loops and vertical lines. In this case, the loops are added to the side of the vertical painted lines.

Type 1.12: These beakers show a straight, often thickened rim with a relatively large diameter. They can bear a red slip but have distinctive rilling on the outside as well, likely created on a rotary device while turning the vessels. These vessels do not have ready parallels elsewhere.

Type 1.14: This unique cup has a straight rim (5.2 cm in diameter) and a well smoothed body with light red slip (2.5YR 6.6). The decoration consists of thin vertical lines, although the paint is faded. A similar cup (QAH1.169) shows vertical lines on a cup with a string-cut base.

Type 2.1: This type shows a slightly sinuous walls and slightly everted rim. They share a decorative motif consisting of vertical lines and hanging and standing double or triple loops. This decoration is paralleled on both jars and beakers, dominating on beakers.

Type 2.1.1: This beaker is a unique variety of Type 2.1 where the painted motif shows a slight variation. It shows the common loops between vertical lines but a unique pattern of hanging and standing triangles, filled with net-pattern and diagonal loops, is painted in the middle.

Type 2.2: These three cups attested at Qarn al-Harf (rim ø varying from 7-8 cm) all have straight sides and a slightly everted rim. The body and base are well smoothed and show a red or brown slip. The decoration is painted between 3 horizontal lines and consists of elongated triangles attached to each other (motif 10) in a ‘butterfly’ effect.

Type 2.3: These cups show straight or slightly inclining walls and a slightly everted rim. The body is well smoothed and red slipped. The decoration consists of groups of horizontal lines below the rim and on the lower part of the vessel, which are usually painted to demarcate the panel for decorating the main motif. In the case of these cups, the middle part is left vacant of decoration. They are related to Type 1.11.

Type 2.4: These beakers and cups feature a slightly everted rim, well smoothed body and reddish-brown slip. The decoration distinguishes itself by mostly showing fine lines, and a tendency to paint multiple fine lines demarcating the decorative panel, and in painting the zigzag chevrons. The decorative motif is among the most commonly attested at Qarn al-Harf and Shimal within this type and consists of zigzag chevrons, between 4-5 lines, painted between double or triple lines. Common morphological features with shared decoration exist but a distinction on the basis of rim diameter is made between cups and beakers.

Type 2.5: These Beakers of this type have a slightly everted rim, smooth base and are often slipped. They bear three zigzag chevrons between double or rarely triple lines. Only in rare occasions is the base roughly scraped, something more common in types 3.1 and 3.2.

Type 3.1: These beakers and cups seem to form a transition from Type 2.4 to Type 3.2. They show a (slightly) everted rim. The body shows a straight wall. The lower part of the vessel is shaved and often shows scrape marks not being further smoothed, showing traces of string-cutting on the base. They yield three zigzag lines between usual double lines.

Type 3.2: These beakers often show everted rims and a straight wall, being wheel-turned with almost cylindrical profile. The bases are scraped and show string-cuts. The decoration consists of double chevrons between single or double horizontal lines.

Type 3.3: These cups have (slightly) everted rims. In the case of QAH5.108, the cup bears no slip and has a scraped base. The decoration consists of a vertical line with diagonal short strokes, resembling branches and likely representing as such. In the case of QAH2A.010, the decoration is applied in a rather irregular way and the motif is painted through the lower demarcating line.

Type 3.4: Cups with this motif show a slightly everted rim and a decoration between single lines of two triangles touching at the tip, filled with net patterns. The motif is created by painting two crossing lines and filling the triangular spaces with diagonal crossing lines.

Type 3.5: These cups most often yield slightly everted rims (rare straight rims QAH6.221-6.222). The bases are usually scraped and not further smoothed and the surfaces are largely left un-slipped. The decoration consists of diagonal crossing lines between double horizontal lines, creating a net-pattern.

Type 3.6: This unique beaker/cup has a rim diameter of 9.8 cm. The walls are slightly inward and the rim slightly everted. Clear string-cut marks are visible on the base and the lower part shows scrape marks. The decoration is painted between three horizontal lines and consists of groups of vertical lines crossed by shorter diagonal lines resulting in a net pattern.

Type 3.7: These beakers and cups show a variety of shapes, though most commonly with straight walls. The bases are invariably string-cut and only roughly scraped. The rims are everted. These beakers and cups mostly have un-slipped yellowish red surfaces, but on rare occasions a reddish slip is (still) applied (for instance: QAH2.057; QAH5.068). Often the inner rim shows a painted line, and sometimes

painted dots are added. The decoration consists most often of a panel created by double lines below the rim and mid-body, and two wavy lines between, painted by a relatively thick brush. However, significant variations exist in the number or presence of delineating lines, and the number of wavy lines.

Type 3.8: This type of beaker is well attested at Shimal and Dhayah, although it is relatively rare at QAH, where it is attested in a single example from QAH2: QAH2.064. The beaker has a clear, almost pedestalled, string-cut base. The wall is slightly outwardly faced, with clear turning marks, and an everted rim. The decoration consists of four horizontal lines below the rim. The presence of clear (red or brown) slip is mostly associated with earlier beakers with smooth bases and straight rims, but significantly (still) in use with this type of beaker.

6.9.4: Characters

For the characters, a combination of multi-state and binary state (present or absent) character states was used. In contrast with the previous case study, where the general groups had multiple character states coded individually by presence or absence, the dominant character (or technically most significant) was taken as the character state for the individual taxa. It must thus be remembered that internal variability is still present in the characters for each type.

In total twenty-three character states were devised of which the first three relate to morphology and technical actions when forming the vessel with an additional character related to the presence of a slip and a character related to the way the decoration was delineated. Eighteen characters relate to the decorative motifs used on these beakers and cups (**see appendix 8**).

6.9.5: Results

When performing the cladistics analysis. An initial concern might be raised regarding the number of parsimony informative (PI) characters. These are 7 out of 23 characters. This is due to the large number of decorative characters which are singular and thus parsimony uninformative. In the dataset represented by Collard, Shennan and Tehrani, there is a biological dataset where the number of PI characters is lower than the number of taxa, referring to Anoles Lizard morphology (Collard *et al.* 2006a, 176, Table 3). This does not seem invalidate the dataset in itself, however, for future

studies, characterizing the data to contain more shared derived characters would improve the robustness of the results.

WS_beakers_22taxa	Scores
# Trees	48
Tree length	36
CI	0.8056
CI excl. uninform. Char	0.6500
HI	0.1944
HI excl. uninform. Char	0.3500
RI	0.8372
Rescaled CI	0.6744

Table 6.6: scores for the Cladistic analysis of the dataset with 22 taxa.

The results are promising in showing a high CI and RI consistent with patterns of descent with modification. The RI of 0.84 is high compared to RI obtained for other cultural and biological datasets (Collard *et al.* 2006a, 176: Table 3). Showing a RI above 0.6, it should be seen as consistent with low rates of horizontal transmission (Nunn *et al.* 2010, 3817).

However, a problem lies in the fact that a lot of the decorative motifs are singular to a certain type of beaker or cup and thus are not shared with other types, rendering them *parsimony uninformative* (autapomorphy, see §3.6; Fig. 3.3). Yet the high CI (nearly always 1) suggests they are consistent with the branching pattern, which is at least useful in typological terms. Moreover, the decoration can be of importance to identify the type, and the evolution of decoration (perhaps independent of the morphological characters) and is relevant to include in either case. It is important to code the decoration, as it helps to define types, and shows a development of decoration which can be seen to be largely independent of the morphological changes.

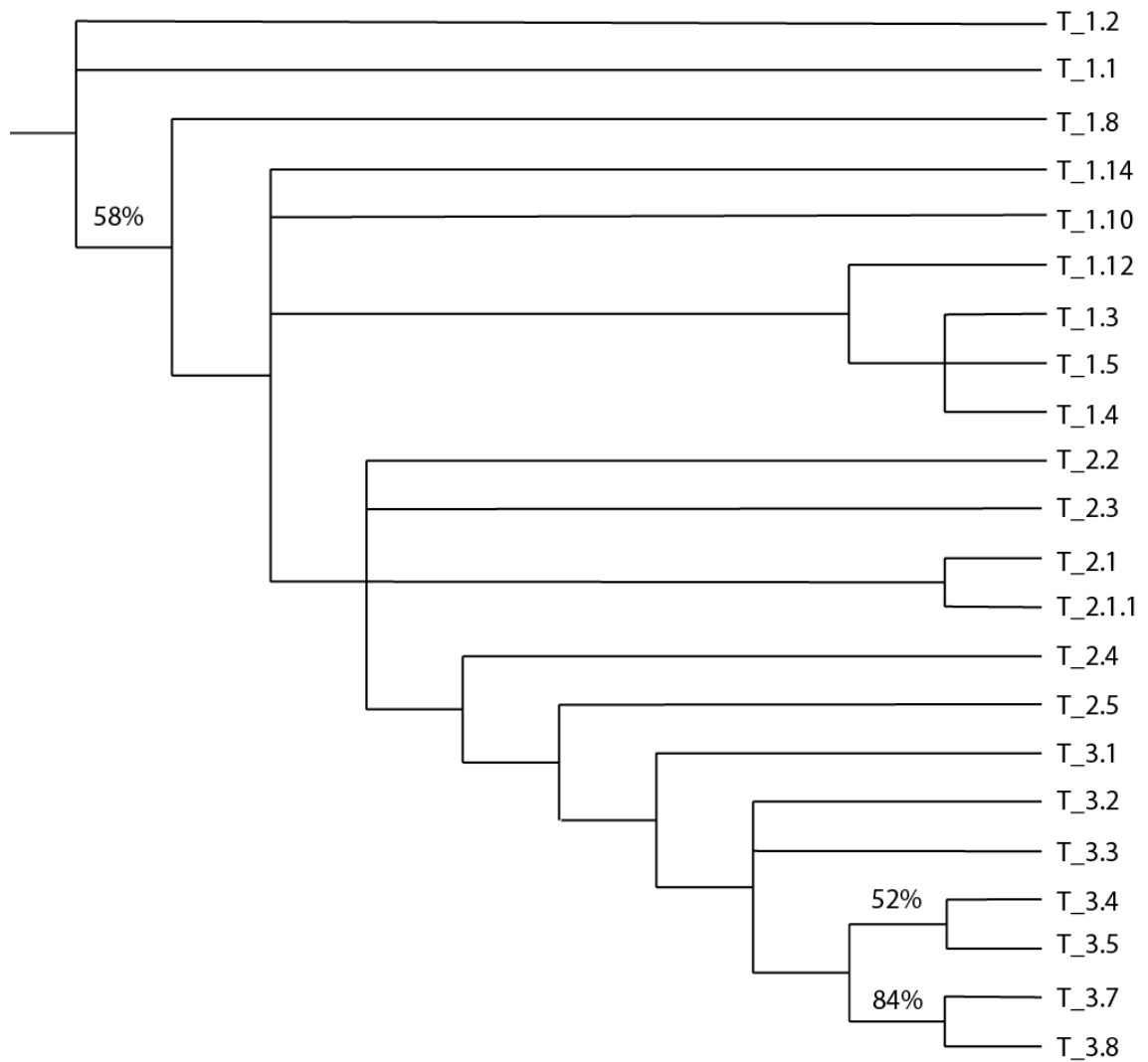


Fig. 6.6: Majority rule consensus tree showing clades present in 50% or more of the 48 trees. Bootstrap (1000 repetitions) shows reasonable support for the clade excluding T1.2 and T1.1 (58%). Reasonable good support for the clade with types 3.4 and 3.5 (52%) and good support for the clade with type 3.7 and 3.8 (84%).

The bootstrap analysis shows that only the clade with taxa 3.7 and 3.8 has a higher support than 70%, which shows it to be particularly robust (Hillis and Bull 1993; Tehrani and Collard 2009b, 293). This in itself is relevant, as it can show that variability was quite dominant in general, but clade 3.7 and 3.8 represent the beakers made predominantly with the (fast) wheel, and are particularly robust in terms of descent with modification, not that many changes exist between the other taxa. Nevertheless, the branching pattern shows interesting results.

	Character	Description	CI	RI
Morphological	1	Body shape	0.67	0.75
	2	Rim shape	1	1
	3	Base type	0.67	0.83
Surface	4	Slip	1	1
Decoration	5	Delineating lines	0.4	0.7
	6	Chevrons	1	0
	7	Thin wavy lines	1	0
	8	vertical lines and multiple wavy lines	1	0
	9	pending loops and lines	1	0
	10	vertical lines and loops	1	0
	11	vertical lines and diagonal loops	1	0
	12	vertical lines and pending loops	0.5	0
	13	vertical lines, triangles and lozenges	1	0
	14	butterfly motif	1	0
	15	3 or > zigzag chevrons	1	0
	16	2 zigzag chevrons	1	0
	17	Vegetal/branch motif	1	0
	18	net-pattern	1	0
	19	vertical lines	1	0
	20	triangles filled with net-pattern	1	0
	23	thick double wavy lines	1	0
	22	thick lines just below the rim	1	0
	23	rilling	1	0

Table 6.7: Individual characters and CI/RI for the characters used in the analysis, generated with Mesquite (Maddison and Maddison 2011).

The CI and RI for the majority consensus tree are given in **Table 6.7**. A number of things might be interpreted from these results. The body shape, rim shape and base type show good individual phylogenetic support with high retention indexes. This suggests in general that a large part of the phylogenetic signal might be explained by these general morphological features. This is significant, as it might be argued that they are most directly linked to the forming stage and, although visible features, they can be shown to related most to the way in which the vessels were made, specifically the way the wheel was employed in combination with coiling or likely by throwing the vessels at a later stage (see Chapter 7: Discussion).

We can test for the assumption that decorative motifs show more tendency for homoplasy, likely due to horizontal transmission and patterns of borrowing, by analysing the RI for character sets. The RI relating to forming the vessel (1-3) and surface treatment (4) together yield a RI of 0.8, very consistent with a phylogenetic pattern. The RI for decorative characters (5-23) yields a RI of 0.54. Thus the RI of decorative characters shows considerable more homoplasy. This would again suggest that decorative characters do show a larger tendency for horizontal transmission. This is in line with the hypothesis stated in chapter 2, that the characteristics of forming a vessel, most specifically related to the use of the wheel, will show good signs of vertical transmission as they are related to processes of learning (i.e. the use of the wheel). This may imply prolonged learning within a potter's community, aided by visual and oral help, but most significantly by learning by trial and error within a group of potters. The RI of individual characters can yield even more information.

The application of slip on the body shows a CI and RI of 1, and is thus fully consistent with the branching pattern. It suggests the initial application of slip and later general lack of slip is thus an important phylogenetic indicator. The number of delineating lines used to frame the part of the vessel to be decorated shows a rather low CI (0.4) but a retention index of 0.7 which suggests that it is relatively homologous and relates well to the reconstructed branching pattern. Thus, the number of lines seems to be related closely to changes in painting introduced by the potters, at least on a local level at Qarn al-Harf.

A problem with decorative motifs is that they show good support for the branching pattern (CI) but generally have a RI of 0, which relates to them being

parsimony uninformative (not being shared among two or more taxa). As such, the RI of many individual decorative traits cannot readily be used to make inferences on the way decoration relates to processes of transmission. However, the high CI would indicate that they do correspond well to a branching pattern. When more vessel types would be used, sharing similar decoration, the analysis would give different results regarding the RI of decorative motifs. With the dataset showing a particularly high RI of 0.84, it may be expected that the data would show little reticulation.

6.10: General Discussion on the cladistics analysis of Wadi Suq ceramics

How has the cladistics analysis of distinct assemblages from Qarn al-Harf aided us in the understanding of ceramic developments in the Wadi Suq?

- a) In the first place, the phylogenetic analyses show technical evolution being quite dominant in the branching pattern. Straight rims are an early feature, developing into slightly everted/everted rims. Red slip is an early feature which is later lost. There is a clear evolution in the finishing of the base which is left more untreated at the end, showing scrape marks and/or string-cut marks. This development must be connected with the increasing use of the wheel, likely for throwing small vessels. This has been seen as a hallmark of Wadi Suq ceramics, but actually seems a feature that is dominant later in the sequence.
- b) Decoration shows important patterns. Significantly, the development in decoration on spouted jars and beakers and cups shows similar developments which can lead us to suggest they are based on shared technical developments through time and identical ways of transmitting ceramic knowledge.
- c) The similar developments in technique (string-cut bases, lack of slip) can be seen as general developments. The similarity in decorative motifs shows these were shared on multiple vessels and between different form-groups and underwent a parallel development in use.

6.10.1: Chronological check

The basic development suggested by the first cladistics case study suggests a ceramic evolution based on the selection of certain ceramic traits which relate to changes in the *chaîne opératoire*. However, we can also attest that these changes are likely to have been gradual.

The evolution attested in the beakers and cups witnesses a clear branching pattern between branches with Group 2-3 and branches with Group 4-5. These groups seem to represent two dominant traditions, one based on wheel finished coil-made vessels (Group 2 and 3), whilst the other would have used the wheel at an earlier stage of forming the vessel; at a fully developed stage of production probably throwing the beakers on the wheel without the aid of coiling, and cutting them off the excess clay with a string. On the one hand one could make an argument that these two traditions were contemporaneous and represent different household workshops of potters displaying different degrees of specialisation in terms of using the wheel. However, a gradual change in morphology and decoration can be witnessed between these types, as they partly overlap, which would suggest that the clade of Group 4 and 5 actually branched off later, and continues when vessels in the earlier tradition are no longer made. This pattern seems to hold up in the tombs at Shimal and Qarn al-Harf. Moreover, it seems to be a pattern distinguishing earlier traditions attested in Wadi Suq tombs and settlements of south-east Arabia, from later developments attested predominantly in the northern Emirates (Jebel Buhais stands out and seems to be in use in this later period). Unfortunately we possess too few absolute dates to further test this hypothesis in terms of chronology, and stratigraphic information from Tell Abraq is not really useful at this stage (Velde 2003; Potts 1989; 1990). We need more single phase tombs or settlements, and good stratigraphic control from rare tell sites to further elucidate this picture.

The fact that similar patterns arise from the cladistics analysis of spouted jars and beakers and cups, suggests that a number of steps in the *chaîne opératoire* are shared between these vessel groups and underwent a similar development. Moreover, the development, or popularity, of certain decorative motifs is also similar in both groups,

both strengthening the cladistics outcomes and suggesting that visual characters, such as decorative motifs, were easily shared between a variety of vessel categories.

6.11: Discussion

In my mind, an important outcome of this second case study is that it shows the potential of phylogenetic analysis to assist in testing a hypothesis about the evolution of ceramics even when relative or absolute dating is problematic. This capacity has been stressed for other material culture, such as Acheulean hand axes (Lycett 2009b, 4). This is the case for the Wadi Suq, with relatively few stratigraphically well excavated sequences, the problem of re-used tombs, and the lack of C-14 dates with distinct assemblages. Hence, cladistics offers an independent quantitative method which states its assumptions clearly and is reproducible, and can be expanded with a better quality of data available for ceramic types. In making use of clear principles of ‘descent with modification’, working on the strengths of this main assumption, cladistics can assist not only in testing developments, but also building hypotheses about the evolution of material culture. As such it is not placing the cart before the horse, but can build testable ceramic evolutionary sequences which can then be evaluated with chronological and geographical data to provide a baseline for an expanding discipline.

6.11.1: Cladistic challenges

Our taxa of vessels are made up of vessels found together in tombs. However, the assumption of descent with modification from a common ancestor is based on the transmission of ceramic practices by potters. Thus, there are two important interpretive steps we need to account for, namely 1) what kind of entity of ceramic production does the assemblage from tombs represent, and 2) can we see it as a uniform entity? The answer to the first question has to be sought in the way ceramic production was organized in general. With a lack of direct evidence for ceramic production (kilns, workshops) from Wadi Suq contexts, we assume a similar system of a group of potters (workshop or household workshop) who were working on a regional scale. The clusters of tombs at the foot of the Hajjar mountains seem to represent different social groups or settlements, probably related to habitation in oasis settlements (Velde 2003; Velde *forthcoming*). In answering the second question, we might also assume that the ceramics from Qarn al-Harf was produced largely by a

local group of potters. However, the large number of fabrics does not exclude the fact of ceramic imports from farther off, as is indeed attested for imports from Bahrain (clearly recognized Dilmun fabrics). Thus, the analysis of Wadi Suq ceramics should be seen as the evolution of ceramics at a regional scale, and thus relating to particular regional trajectories. General similarities in the development of ceramics are apparent throughout south-east Arabia (Carter 1997a). However, it is likely that the technical skills of potters differed between areas in south-east Arabia. For instance, the presence of the wheel to actually throw smaller vessels might not readily be assumed at Wadi Suq sites such as al-Akhdar in Oman, where no clear traces of such technique are either mentioned or illustrated (Yule 2001). This suggests that the general style might have been transmitted between communities, but specific techniques, such as the full potential of the wheel, depended on closer contact and specific transmission. This would suggest that the evolutionary pattern largely applies to different regions on a general level, based on similar local conditions of ceramic use, and partly due to the fact that ceramic traits were transmitted between these regional groups of potters. However, as has previously been stated, the real way to pinpoint these differences in production between regions starts with a more detailed study of the clay sources and petrographic analysis of the vessels, together with more in depth considerations of locally used *chaîne opératoire*. This is something to be done in future projects.

6.11.2: Archaeological atavisms:

Atavisms seem to have been an important feature in ceramic evolution, which need to be accounted for. In biological terms, an atavism can be stated as a “reappearance of a character state typical of a remote ancestor in an individual that really shouldn’t have it” (Stiassny 2003, 10). In cultural or ceramic terms it would suggest an archaic feature. When the presence of atavisms is suggested in ceramic data, it might suggest that ‘speciation’ is not very robust, and it is easy for certain characters to revert, as this reversion does not involve many steps in the *chaîne opératoire*. Thus, it would suggest that ‘speciation’ between ceramic types, if we can call it such, is not fully developed. This would make sense in a rather low-key quite regionalized ceramic industry such as for the Wadi Suq. Moreover, when we observe the presence of types of ceramics from a different generation of potters within the same tomb, it should not be surprising that the reversal to characters observed by these potters in older ceramic

types was easily realised, and in itself fits the idea of technical agency of ceramic vessels as discussed before (§2.5.1).

6.11.3: Character reversal of the spout.

An important result suggests that spouted jars show character reversal in the position and execution of the added spout. It seems that the earliest vessels (including the outgroup QAH6.002) had spouts added to the shoulder of the vessel, underneath the rim, and were not added to the rim itself. From this position the spout seems to evolve into a rim-spout, showing the same perforation of the body, but with the spout added to the vessel and running up to the rim, with a U-shaped gutter opening. This then evolved into spout with a pinch between rim and spout, after which the spout seems to evolve (back) into a shoulder spout, however, mostly with a marked, widening trumpet-shape. This result is significant in more than one way. It shows that the position of the spout cannot be taken as an absolute chronological indicator *a priori* without taking other characteristics into account, and archaeologists should refrain from such conclusions when for instance only finding a spout fragment. Secondly, it shows that character reversal can be quite common, especially in a more heterogeneous production, and potters can resort to using ‘older ways’ of doing things quite easily when they deem this desirable.

Thus, an important development that we see influencing the evolution of ceramics but that also features in biological evolution is atavism (Stiassny 2003). The phenomena of character reversal, where a character reverses back to an ancestral trait and is even shared in a group of taxa (clade) is called taxic atavism, and might be explained by a reversal of the potters to a remembered trait which fell out of practice in ceramic production, but is deemed suitable again and re-introduced in the *chaîne opératoire*. These character reversals go against the rules of parsimony, and are thus problematic for an evolutionary reconstruction based on methodologies such as cladistics. One answer might be in coding a character reversal differently from its ancestral form, if it is really distinguishable. However, this remains artificial.

6.11.4: Character reversal of wavy lines as decoration

As previously discussed, wavy lines feature on late Umm an-Nar Sandy Red Ware, but are also dominant in Wadi Suq ceramics. This would suggest that even though wavy lines are an ancestral trait, they were not very common as decoration during the

early production of Wadi Suq vessels, but gained popularity again at a later stage of production (connected with wheel-made, string-cut beakers and cups, and spouted jars). It might be suggested that the relative quickness and ease of painting two wavy lines on a ceramic vessel is connected to a stage of ceramic production where the importance of the decoration was no longer as crucial as during the previous stages. We will take up this discussion in more detail below.

6.12: The role of ceramics in the Wadi Suq period.

6.12.1: Wadi Suq ceramics, an emic style incorporating many local wares?

Of course, suggesting that culture has a start or end point based on ceramic evidence is a rigid, artificial way of displaying cultural processes (Campbell 1999; Campbell 2007). However, within cultural processes, there are periods when change is more distinct and rapid than at other times, and which usually warrants a new archaeological label for a particular cultural period, such as the ‘Wadi Suq period’. The narrative can fortunately be shown to be more complex and interesting in that the Wadi Suq period, or more generally the start of the 2nd millennium BC in south-east Arabia, sees a dual inheritance of localized wheel-made production and the incorporation of decorative designs from more specialised (disappearing) production from the previous 3rd millennium BC as has been argued for the Wadi Suq ceramics. This inheritance can be seen in the ceramic record, the tomb architecture and in other material cultural traditions (§5.6; 5.8). It is this dual inheritance of two types of tradition regarding the level of specialisation which can actually be seen as a ‘hybrid’ start to the 2nd millennium BC, which came forth from strong cultural changes at the end of the preceding Umm an-Nar period. These changes can be related to environmental degradation (aridification) and the reorientation of the widely connected international trade via the Arabian Gulf; processes which are intrinsically linked. It can be suggested that the Wadi Suq period saw a refocus on locally produced decorated ceramics, which played a powerful role in acts of communal consumption strongly connected, but far from exclusively catering to, funerary rites and communal interment of the dead.

For the Wadi Suq period in south-east Arabia, the discussion has not so much focussed on this difference in ‘styles’ and ‘wares’ thus far, although the presence of various fabrics and local production within a more general style has been

acknowledged. However, this is in need of further archaeological research programs incorporating petrographic and chemical studies. Phylogenetic analysis of spouted jars and the category of beakers and cups points out that, in the first case, the phylogenetic signal is not particularly strong, perhaps due to the occurrence of substantial character reversal, particularly in the placement of the spout which seems to be fairly flexible in terms of shape (§6.11.3). Yet in the case of beakers and cups, a clearer discernible pattern of descent with modification becomes apparent. This pattern must again be primarily related to technical decisions related to the use of the wheel, as this drives certain decisions, such as the finishing of the base, the shape of the beakers and cups, and likely extends to the time spent on applying slip and decoration. Thus, the possibilities opened up by the use of the wheel to form ceramics which ultimately resulted in fully forming the shape on the wheel (throwing), was surely a very strong driver in ceramic evolution.

In terms of decorative motifs, it is clear that inspiration was drawn from the wider Arabian Gulf, shown perhaps most emphatically in the motif of antithetically placed caprids facing a tree, which is a recurs widely in societies around the Gulf and the Near East in the Bronze Age (ceramics and soft stone) and Mesopotamia (**Fig. 6.7**).

It is uncertain to what extent this motif, sometimes related to the ‘tree of life’ motif, had the same underlying meaning to potters who copied it from 3rd millennium BC traditions, painting it on a Wadi Suq vessel, though the thought is attractive to ascertain (Orlin 2015, 964). In any case, at the start of the 2nd millennium BC, potters in south-east Arabia started to develop their own themes and decorative schemes, based on local preferences.

Thus, ceramic traits which rise due to local conditions can be copied by potters because of processes of emulation, but probably with changing meanings in local contexts. This is quite clear in the case of Tell el-Yahudiya ware decoration (§4.8.8). Perhaps most significantly, this approach offers an argument against the view that would see stylistic change as ‘stochastic’ in nature, and so distinguish it from ‘functional’ traits (§2.4.1-2).

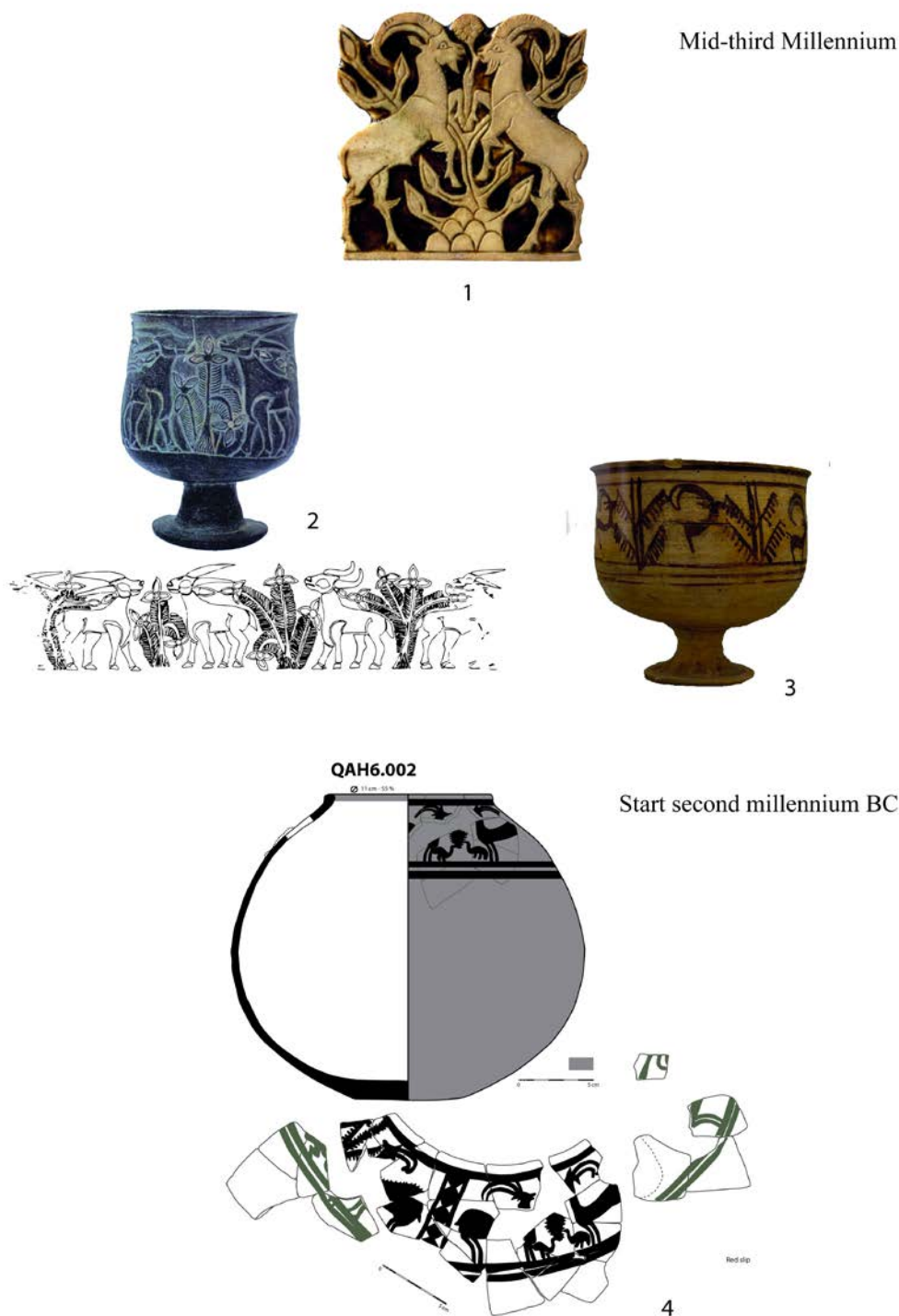


Fig. 6.7: The motif of (mostly) antithetically placed caprids is popular throughout the 3rd millennium BC on diverse artefact and media and was transmitted to early Wadi Suq potters. **1**) 3rd millennium BC (around 2600 BC) Shell inlay from Ur (courtesy of British Museum), **2**) 3rd millennium BC soft stone vessel from Konar Sandal (Iran) (Madjidzadeh 2008, 28) **3**) a footed goblet from Shahr i-Sokhta (Eastern Iran) (courtesy of wikimedia commons by Emesik), **4**) Early Wadi Suq jar from the tombs at Qarn al-Harf (M. de Vreeze) (images not to scale).

Stylistic traits such as decorative patterns evolve according to local conditions which are equally embedded in technique and cultural meaning, but can be copied by potters working in quite distant places connected by trade where this meaning may be lost or renegotiated. It is at this stage that stylistic change can become random in appearance. This, however, would need further statistical testing with larger assemblages. It does suggest that the scale at which stylistic change is observed is crucial; whether within a single site, region or cross-regionally.

6.12.2: Structuring social cohesion

Social cohesion negotiated through kinship groups has recently been suggested as a unifying principle for communities living in the Arabian Peninsula, and as a cause of the negating of social forces spinning towards hierarchy and social inequality (Magee 2014). This is much in line with the focus on social cohesion that Cleuziou calls ‘alliances’ (Cleuziou 2003). Following these ideas, we can see a continuation of communal tombs, at least in the northern Emirates, associated with a majority of ceramic vessels intended for consumption, likely to be shared by larger groups. The focus on decorated wares for feasting is far from new in the region, but has its incipience in the Neolithic when, as mentioned previously (§5.8.2), Ubaid pottery brought from Mesopotamia fulfils a similar role (Carter 2010). The 3rd millennium BC Umm an-Nar ceramics likely had a similar function, but perhaps there is a focus on vessels used as containers in the form of small necked jars. However, local production started to provide for vessels used in household contexts and interred in the tombs, mostly in the form of oval jars, sporadic beakers and cups, and even more rarely spouted jars, as for instance seen in Hili tomb N (Al Tikriti and Méry 2000). We can now clearly suggest that this pattern was continued at the start of the Wadi Suq period, with a reinforced focus on local production, and a particularly strong focus on decorated vessels, as attested in the tomb. The focus on beakers, cups, and spouted jars would suggest a particular importance for the act of drinking beverages. Drinking can be seen as an integral part of feasting and rites surrounding the dead (Dietrich *et al.* 2012; Joffe 1998; Sherratt 1995).

6.13: Conclusion

Coming back to Carter's (1997a: 106) suggested inability of archaeologists to distinguish stylistic evolution in ceramics during the first half of the 2nd millennium BC, the evidence from Shimal as presented by Velde (*forthcoming*) and cladistic results from the Qarn al-Harf ceramics provide a sound base to counter this observation. Cladistic analysis shows that an evolutionary development within two subgroups of beakers/cups and spouted jars is tangible and shows 'descent with modification'. However, the evolution of ceramics is never straightforward. Instances of retaining or regaining ancestral traits occur and are easily explained when considering the heterogeneity of ceramic production and the limited amount of time of around 500 years. Moreover, some processes of transmission, particularly related to the decoration, seem to follow different rules. However an important conclusion that can be drawn on the basis of this study is that particular choices in *the chaîne opératoire* related to the use of the wheel show strong cohesion with a pattern of descent with modification. These changes in the use of the wheel can be suggested to be strongly related to localised ceramic practices inherited by potters within confined groups and transmitted through generations. Thus stated, the likely increased use of the wheel for throwing vessels, or executing more steps in the forming process on the wheel, can be observed, and show a distinctive evolution based on vertical transmission. As suggested, more visible characters, for example decoration and morphological features such as spouts were easier to copy by potters outside a certain 'community of practice', and could likely be attained through visual and verbal communication with other pottery communities, and specifically by copying vessels which were exchanged between communities. Unfortunately the information on the fabrics would need more detailed study to follow these patterns. It might show similar conservative processes, though the heterogeneity of the fabrics is observed at Qarn al-Harf and already noted for other sites. More detailed petrographic study of assemblages from different sites might relate the observed patterns better to local production and identify vessels which were clearly brought in from other locations. Moreover, it would establish more thorough links between the organization of potters and how these relate to assemblages interred within tombs.

Concluding from a methodological point of view, these analyses show the worth of applying phylogenetic analyses, even to groups of artefacts which have less strict

chronological control. If cladistics analysis can help argue for a clear development in ceramic practices on the basis of patterns of descent with modification in the production sequence, this can add further support to regional and chronological developments and be placed in a wider narrative of change within the society.

Chapter 7

DISCUSSION AND CONCLUSION: CERAMIC EVOLUTION AND THE NARRATIVE OF CHANGE

7.1: Part 1: insights into material cultural evolution

Does our taking an evolutionary viewpoint, and an explicitly phylogenetic approach, to the study of ceramic change aid our understanding of these processes and help us to relate them to wider cultural and environmental processes? To this question I must answer with an emphatic yes, despite the fact that the previous chapters have shown that serious hurdles remain when working with archaeological data in general, and ceramic data specifically. This chapter will start with some of the theoretical insights that the analyses have given in terms of the way that we should approach ceramic evolution. It will subsequently focus on how these insights can help inform and even modify the current ceramic narratives of the two major case-studies. Finally, it will readdress the role that quantitative evolutionary approaches can play in archaeological ceramic studies, and discuss some of the problems and challenges that arise when ceramic data are examined using phylogenetic approaches.

7.1.1: The *crucial concept of the chaîne opératoire*

As pointed out repeatedly throughout this thesis, the concept of the *chaîne opératoire* forms the crucial theoretical and practical approach which helps us examine characteristics in ceramic production and their evolution. This is because it is within the *chaîne opératoire* that mutations occur and selective pressure operates. Moreover, within this thesis it is seen as the main analytical connection between the agency of objects and human beings, and for archaeological artefacts in general. It also offers a tool that we can use to untangle the 'entanglement' of object and human actors which has been stressed in recent materiality studies (§2.5). However, the question of archaeological visibility of this *chaîne opératoire* remains a formidable challenge for ceramic analysis. With the lack of excavated locations of production (workshop or household), the organization and technical tools of production must be inferred from traces observed in the fragmented ceramic material itself (or even deduced from publications), and experimental studies (as done for the Tell el-Yahudiya juglets), together with inferences from related ceramic traditions. However, this in itself remains challenging as not all steps in the production sequence are easily recognizable, due to the way ceramic material is published, the fragmentary nature of

the material itself (when whole the vessel is not preserved) or the obliteration of many traces of production by later actions (§2.3.6). Hence, within this study, consideration of the *chaîne opératoire* has helped firstly by informing the choice of characteristics for analysis, and secondly by establishing the link between changes in ceramic technical traits and human action placed in its social environment. This link is crucial when trying to get to grips with the reasons for ceramic evolution – not just to describe the process but to understand it. It is clear that if archaeologists choose to use phylogenetic methods, the approach will work best when as many steps of the *chaîne opératoire* as possible are deducible from the material studied.

7.1.2: Specialisation

The degree of specialisation of the potters responsible for the ceramics studied in this thesis remains conjectural and based on archaeological inferences. A significant element in discussions on specialisation is the use of the wheel, and the way communities of potters would have engaged with the wheel. It is within this context that this thesis has insights to offer. Tell el-Yahudiya ware can be argued to have been part of a specialised industry in some areas of the Northern Levantine coast, and Nile Delta: Tell el-Dab^{sa} in particular, though it was also part of a more general ceramic output that was focused upon juglets. The latter situation seems to have dominated the Southern Levant, where locally produced Tell el-Yahudiya vessels were a decorative adaptation within more localized traditions of juglet production. The Wadi Suq ceramics studied in the second case study seem to show a lower level of specialisation with many dispersed production units, likely with a particular momentum seen in the Northern Emirates which needs further exploration. Crucially, the evidence suggests that the requisite techniques were being introduced by specialist migrant potters in both cases that subsequently evolved through their local momentum, bringing us to the discussion of independent itinerant craftsmen.

7.1.3: Independent itinerant craftspeople

Independent and itinerant craftspeople very likely played a crucial role introducing innovative techniques of production in the Egyptian Delta (Dab^{sa}) and south-east Arabia. At some point the agency of ceramic production, especially the use of the wheel, must have changed the established practice of copying observing traits present in imported artefacts to the communication between potters of new techniques within

local settings, akin to an apprenticeship. It is likely that independent, itinerant craftsmen were responsible for the introduction of the wheel for forming, and ultimately throwing vessels of small size on the ‘fast wheel’ in south-east Arabia, and in the Southern Levant and eastern Nile Delta. In both case studies, ceramic production, including the use of the wheel, then followed its own local trajectory adjusting to local conditions in ways which were mediated socially between potters and consumers. The idea of itinerant craftsmen spreading techniques is far from unique to pottery-making, and arguably played at least a partial role in other craft development in South-east Arabia, such as copper ore extraction and metalworking (Cleuziou and Méry 2002, 304; Weeks 2003, 36), and perhaps even agricultural techniques (Tengberg 2012).

As others have shown (Bourriau and Phillips 2004; Broodbank 2013; Steel 2013), the sharing of techniques and crafts is a crucial component of the cultural formation of the Middle and Late Bronze Ages of the East Mediterranean as these are generally understood, i.e. within an interregional sphere of ‘elites’. A particularly striking example of such reciprocal Mediterranean craftsmanship is found in the ‘Minoan’ style wall paintings which were likely produced by artists originating in the Aegean world and employed to adorn palaces and residences at sites such as Knossos, Akrotiri/Thera, Alalakh, Tell Burak, Qatna, Tell Kabri and Tell el-Dab’a (Bietak *et al.* 2007; Broodbank 2013; Brysbaert *et al.* 2006; Cline 1998; Rüden *et al.* 2011; Steel 2013:121). At the same time, similar wall paintings were likely copied in more ‘Egyptianizing’ style by local artists catering to elite taste, as evidenced in wall paintings at Tell Sakka in Syria (Taraqji 1999, 38: Fig. 10). The last site interestingly shows Tell el-Yahudiya ware in local style, suggesting both ceramics and wall paintings were forming part of such local processes of emulation in an ‘Egyptian’ or perhaps rather early expressions of the ‘International Style’ (Taraqji 1999).³¹

The distribution of Tell el-Yahudiya ware must thus be placed within this framework. The vessels were first traded as luxury containers from the Northern Levant to Egypt. As the ‘Delta identity’ grew stronger, Tell el-Yahudiya ware became part of a trend to emulate ‘international ‘Egyptian/Delta’ styles by local communities in the Southern Levant (Chapter 4). The production gains a particular momentum in

³¹ Morandi Bonacossi (2014,422) interprets the building at Tell Sakka as a summer residence for rulers from Damascus.

the eastern Nile Delta (foremost at Tell el-Dabʿa) due to its tight connection with the local funerary cult wherein the vessels were consumed in significant numbers – as were other types of juglet – and the massive increase in population resulting from the growth of Tell el-Dabʿa and other smaller centres in the Delta such as Tell el-Yahudiya. Outside the particular context in the Delta, foremost attested at Tell el-Dabʿa, Tell el-Yahudiya juglets were probably part of the more general emulation of ‘Egyptian’ or even ‘international’ styles, copying the decoration in local production. Similar processes are attested in other media for example in the local production of Egyptianizing stone vessels and scarabs in the southern Levant (Sparks 2007; Ben-Tor 2007). The status of potters as craftspeople travelling the Eastern Mediterranean in search for employment in the Middle Bronze Age is not immediately apparent. For instance, the absence of pottery from international correspondence, save for implied containers such as storage jars, has been suggested to indicate that it was of relatively low value (Moran 1992; Steel 2013, 108). Nevertheless, Steel (2013: 108) has recently argued against drawing overly general conclusions on this point. Added to this, even if ceramic vessels themselves could vary in value, it might have been the skill of producing such vessels in particular which was recognized as a valuable good. What is clear is that in both the Eastern Mediterranean and the Arabian Gulf, the migration of potters must be seen as part of a wider network of ‘immigrants’ catering to local needs and riding — or rather sailing — on the back of the wider Bronze Age international trade in precious goods. The main goods traded internationally at this time were perhaps copper and tin, yet other commodities, often less visible such as edible goods (food, drinks and spices, wine and oil) and textiles should not be underestimated (Wilkinson 2014b; Steel 2013, 112). Small juglets, including Tell el-Yahudiya examples, represent part of a widespread trade in fragrances, as has been recently argued in the framework of ‘branding’ by Lesley Bushnell (Bushnell 2013; Steel 2013; see §4.13.2).

7.1.4: The skill involved: particularly the use of the wheel

The skill of the potter involved in forming and decorating ceramic vessels is elementary to the way such ceramic vessels evolve. One key skill which has come to the fore as being essential in understanding ceramic evolution of both Tell el-Yahudiya ware and Wadi Suq ceramic vessels is the use of the wheel, and the degree in which rotary kinetic energy could be used to actually form vessels on the wheel

(§2.3.3). Wheel throwing of vessels is a technical skill which has been shown to take considerable time to learn and which happens within a clearly demarcated technical tradition; either within a household or workshop environment. Thus, when it appears in a new location then we can strongly suggest the (vertical) transmission of the technique by migrant potters (§2.6).

In both case-studies, the use of the wheel thus seems to have been introduced by potters from outside communities separated by the sea; in the case of Tell el-Yahudiya juglets by potters likely heralding from the northern Levant; whereas particular forming techniques typical to Cypriot production were introduced by migrants from the island. Comparably, in the case of South-east Arabia, potters likely migrating from South-east Iran (Makran/Baluchistan) introduced highly skilled, wheel-made ceramic techniques to south-east Arabia. Both case-studies provide evidence that developing maritime networks of interaction were crucial in breaking down old boundaries in terms of more locally-bound technological traditions. This recalls the effect of the sea and seafaring techniques as ‘Transmission Isolating Mechanisms’ (TRIMS) (§3.3), which transformed into what we might label as ‘Transmission Aiding Mechanisms’. This was perhaps largely due to better maritime technology which facilitated a greater quantity of sea-borne movement than had previously been the case, although these had strong 4th and 3rd millennium BC precedents, especially in the Gulf (Broodbank 2013; Carter 2012; Cleuziou 2003; Wachsmann 1998). Moreover, local communities showed the cultural openness to accept new techniques and learning crafts. The strong influence of maritime techniques and seafaring on patterns of trade and cultural change around the Mediterranean basin have been argued for the Eastern Mediterranean in particular (Broodbank 2013; Wachsmann 1998), and while the topic has received much less study, this must surely also apply to the Arabian Gulf (Carter 2006; Carter 2012; Cleuziou 2003; Magee 2014).

In both case-studies, we had had to deduce the role of the wheel from the ceramic evidence, either published, or studied at first-hand, as no actual workshops or direct remains of wheels are preserved. The problems in recognizing and interpreting wheel-marks have been previously discussed (§2.3.2). There are unresolved questions related to the exact use of wheel throwing as a technique in both case-studies. This provides a particularly good opportunity for the area of south-east Arabia, where the

use of the wheel is understudied and in dire need of both quantification and qualification regarding the different more localized production units. Despite being understudied, it may already be confidently suggested on the basis of the results of the phylogenetic studies in Chapter 6, that forming vessels on the wheel was an important technical driver in ceramic evolution in both regions, specifically related to the inherent (but not always used) potential to form vessels at higher rates of production. These results run somewhat counter to the views of Knappett (2016) who uses the adoption of wheel forming techniques in the Mediterranean (Aegean) to argue against the use of evolutionary approaches. Knappett (2016: 97-98) sees two major problems with (neo-Darwinist) evolutionary approaches to the transmission of techniques, such as wheel-throwing. A first problem is the perceived reductionist approach of the transmission of cultural traits; it fails to take full account of the environmental and social context of learning such new skills. A second problem is the view of cultural practices as divided into distinct ‘traits’ which simply get transmitted upon contact. He thus argues for a more nuanced approach where techniques are socially *embedded* in particular craft practices, and where newly introduced craft practices could both be accepted or chosen not to be accepted by local craftspeople. *Contra* Knappett’s critique of using evolutionary approaches, I argue that by placing the role of the wheel within a framework of the *chaîne opératoire* as inherited information, which is indeed to be embedded within its unique local context of learning, it emerges as a key evolutionary feature, which is traceable with phylogenetic methods such as cladistics and phylogenetic networks.

The growing reliance upon wheel-forming techniques seems to take emphasis away from decorating the vessel more elaborately, a pattern that has been recognized in both case-studies. As such, the wheel need not necessarily have been adopted because of its potential to improve efficiency in either case study. It was likely seen more as an item of cultural prestige and connected to the prestige associated with knowledge introduced by itinerant potters. It may have gained acceptance or popularity because of its initial foreignness, and, equally significant, then underwent a localized development through experimentation, a cultural driving force in both the Eastern Mediterranean and Arabian Gulf, that has been widely theorized in anthropology (Helms 1988; Roux 2015a). The same principle can also be argued in

the Aegean in the Middle Bronze Age (see now: Knappett 2016, for a recent overview in the light of evolutionary studies).

7.1.5: The agency of persons and objects; Materiality

“There is a clear relationship between knowledge and the agency of objects; the further an object travels the more the knowledge about it becomes partial and contradictory” (Helms 1988, 127; cited in Steel 2013, 56).

The difference between the technical agency of an object compared to the agency of personal transmission of technical knowledge between individuals, is particularly relevant for both case-studies. Phylogenetic analysis of piriform juglets has pinpointed a ‘moment’ where the agency shifts from being predominantly based on travelling objects themselves, towards the agency of potters communicating their skill directly within the settlement of Tell el-Dab’a (§4.11.1). From this point onwards, the agency of objects being produced in the eastern Nile Delta clearly communicate technical traits which are copied within other settings such as to potters in the Southern Levant. This is observable in juglets from for instance Jericho and Tell ‘Ajjul, produced in the Southern Levant, which seem to be embedded in more localized ceramic practices and maintain typical technical elements of Levantine traditions such as ‘button’ bases and double loop handles, which seem to last longer in the Southern Levant than in the eastern Delta, but also adopt the easily transmitted new decorative patterns that draw upon practices rooted in the Nile Delta (Kaplan 1980, 281-283; Fig. 61; Kenyon 1960, fig. 142.5; 315-330, fig. 122.4).

In south-east Arabia, one can argue that a ‘dual inheritance’ took place. Some decorative elements were taken over by potters at the start of the Wadi Suq period, drawing upon earlier, well-established Umm an-Nar traditions of painting seen on ‘Black on Red ware’. It is likely that knowledge of pottery making was partly restricted to specialist potters at this time. However, the use of the wheel was adopted within localized household production during the preceding Umm an-Nar period and became entrenched in localized ceramic industries in the following Wadi Suq period. Local potters copied painted decorative motifs, which they knew from imported vessels, and locally produced examples. However the agency of these decorations must have changed from externally inspired to expressing local cultural ideas, as potters chose to rearrange the motifs and found inspiration in the local environment and novel combinations of decorative patterns relating to changing aesthetics.

7.1.6: The visibility of traits and ease of transmission

The visibility of the traits, and the way of transmission is tested by looking at the Retention Index of these features. These show interesting results. As theorized, highly visible traits, which need relatively little skill to copy, will transmit horizontally over a wide area. This would lead to an expected lower RI for such traits. Less visible traits, such as clay recipes and forming techniques which are more conservative and rooted in local environmental conditions and systems of apprenticeship, would incline towards vertical transmission within a clear production setting, and such character traits are expected to show a high Retention Index. The RI for decorative traits in Wadi Suq spouted jars (§6.7.2) and beakers and cups (§6.9.5) are indeed shown to be lower. However, in the latter case the RI (0.54) does not fully conflict a branching pattern and might suggest that these decorative traditions are being influenced by local selective pressure, mostly due to the use of the wheel and an inclination to simplify the decorative pattern.

7.1.7: Wheel throwing and decoration

As seen in both case-studies, the role of the wheel in shaping the vessels can have a large (if not dominant) influence on evolution of both shape and decoration. The causal connection to decoration is important and has not been adequately explained before. The use of the wheel thus represents a fulcrum in technical evolution and this likely extends beyond the present case-studies to apply to ceramic evolution in general, although in each case placed in its own local dynamics. Nevertheless, the social transmittance of the technique of using the wheel can undergo vastly different patterns or even be actively ignored (Knappett 2016; Arnold *et al.* 2008). In the case of Tell el-Yahudiya juglets, phylogenetic analyses suggest that the use of the wheel can be argued to cause a ‘punctuated equilibrium’, a sudden change in production within a relatively short period of time, causing a shift in the production of these small juglets. The role of the wheel, and its connection to the loss of decoration, has been previously discussed for different archaeological periods (Campbell 2008; Berg 2013). Another critical point against the idea of decorative styles being ‘stochastic’ and ‘neutral’ (§2.4.1) might be offered by looking at the cultural meaning of particular decorative patterns. Although these are hard to grasp, previous research has pointed to the presence of such inherent meaning (Campbell 2008). As has been addressed in Chapter 4 (§4.13.1), a strong case is made for an intrinsic meaning for

certain decorative patterns on Tell el-Yahudiya juglets, connected to the eastern Nile Delta, and possibly to fragrances such as the lotus/lily. It is likely that these aspects were intrinsically linked to the use of these juglets in the funerary ritual and perhaps even incorporated to express aspects of both a ‘deltaic’ identity, and to refer to the use of fragrant oils such as the white and blue lily. However, this cannot (yet) be pinpointed by lipid research (Rottländer 2012).

7.1.8: Units of analysis

Both analyses on Tell el-Yahudiya ware and Wadi Suq vessels suggest that the most appropriate unit of analysis for ceramic change is that of a group of potters, and with change viewed as knowledge transmission between groups of potters. A hypothetical group of potters, either working within a household setting or an organized workshop, is a good theoretical basis and avoids the challenges inherent in attempting to define individual craftsmanship, although it can be recognized in the material culture. However, both case-studies face issues establishing these units concretely since no direct archaeological remains of potters’ workspaces have been explored in detail for either area, although more knowledge exists on some workshops in the northern Levant at, for instance Tell Arqa, and the type of pivoted basalt wheel in use there (Roux 2015a). The unit of production needs to be inferred by looking at technical actions and localized context. A challenge lies in inferring these groups from the nature of the context, this being predominately funerary deposits for both case-studies. While such contexts do not necessarily offer a direct link to locations of production, macroscopic information does indicate local ceramic fabrication in both case-studies.

In the case of the Tell el-Yahudiya juglets, some significant patterns have already been established using petrographic research and chemical analysis (Cohen-Weinberger 2008; 2011). Preliminary petrographic analysis undertaken on a small assemblage from Shimal and Hili suggests similar localized production (Méry 1991b; Méry 2000). A future way forward for the Wadi Suq material would be to conduct larger scale petrographic and chemical analyses on a range of ceramic assemblages from different locations, which can subsequently bring these production units into focus within their local settings. Moreover, by focussing on the different levels of transmission of ceramic knowledge, these units might become more visible. As has been hypothesized (§2.6), borrowed traits become transmitted in a branching pattern;

i.e. ‘descent with modification from a common ancestor’, when situated in a clearly defined production unit such as a workshop or group of potters. The phylogenetic results in this thesis seem to corroborate this hypothesis which is predominantly linked to the use of the wheel by select groups of potters. Thus, the process of social selection on the changes in ceramic traits becomes crucial, as these are mediated through the choices that a potter makes in the use of material, techniques and finishing of an object.

7.2: Phylogenetic insights on ‘styles’ and ‘wares’

An important question for archaeological data, both in the Near East and for the wider discipline, that arises from the present case-studies, is whether phylogenetic approaches and evolutionary theory offer insights into the distinction between archaeologically defined ‘styles’ and ‘wares.’ For example, Eliot Braun has argued for a clearer definition of what constitutes a ‘ware’ within the context of the Early Bronze Age Southern Levant (Braun 2012). He states that a ‘ware’ should be seen as a specific ceramic ‘tradition’ based on a suggestion by Roux (Braun 2012, 6).

Braun proceeds to ‘test’ the coherency of certain wares based on his own experience in a very practical way (as a pottery expert), yet refrains from offering a more robust theoretical approach to the difference between ceramic style and ware. In this sense, evolutionary approaches are useful to formalize the distinction between a ‘style’ and ‘ware’ more strictly, by elaborating upon their relationship to expected patterns in the transmission of ceramic knowledge. The approach in this thesis suggests that the nature of the ceramic technology and the transmission of ceramic knowledge are crucial in distinguishing between a style and a ware.

Braun (2012: 5) harkens back to an older definition based on Rice’s (2005: 5, 287) keystone work for the wider discipline of ceramic studies, defining a ‘ware’ as: “Vessels so categorized are recognized as having substantial, common attributes such as function, decoration, paste composition, texture, colour, surface treatment, firing technology and location or presumed point of origin.” He complains that ‘wares’ as they often appear in the archaeological literature, frequently lack these well-defined parameters, and that the term is rarely based on scientific analysis (Braun 2012, 5). What seems clear is that defining a ‘ware’ can easily become a circular argument in ceramic ‘reading’, as a vessel is defined as a certain ‘ware’ and subsequently comes to

define it. Moreover, it need not reflect anything that past potters would have defined as a meaningful unit. Tell el-Yahudiya ‘ware’ seems a good example and illustrates this process well, as it seems to function as a catch-all term that in fact encompasses distinct units of production fabricating vessels decorated in similar styles. It is thus important that phylogenetic analysis clearly suggests that the group of vessels that is usually termed Tell el-Yahudiya ‘ware’ is actually made-up of material resulting from many different processes of transmission, and should be broken down into a number of different localized ‘wares’ sharing similar surface treatment. Importantly, phylogenetic methods allow us to see through ‘traditional categories’ that still shape much of our archaeological discourse. The definition of a style and ware can be improved by placing them in a hierarchical order based on the scale (geographical and temporal) and the related mode of transmission of ceramic knowledge responsible for the shared character traits, that is by focussing predominantly upon the spatial and temporal context of ceramic traditions. Secondly, phylogenetic methods can help qualify the ways of transmitting ceramic knowledge which can then be further qualified.

7.2.1: A ‘ware’ in ceramic evolutionary terms

Thus stated, a ‘ware’ would show a high level of integrity in terms of production (a particular *chaîne opératoire*) most likely linked to a limited geographical locale which can be recognized through a particular petrographic signature. The last statement implies that there should be a recognizable recipe for paste and temper. The choice of clay source is one of the most conservative steps in the production and changing it would constitute quite a radical shift, as discussed by Arnold, a view which fits the model of petrographic integrity of a certain ware (§2.4.6). In terms of phylogenetic signal a ware would show a clear branching pattern suggesting descent with modification from a common ancestor, if enough steps can be identified within its *chaîne opératoire*.

7.2.2: A ‘style’ in ceramic evolutionary terms

A group of vessels in which the examples share characteristics, while the group as whole lacks phylogenetic integrity, thus indicating a large amount of borrowing, probably therefore in combination with production at different locales, is better addressed as a style. This is a more inclusive term which could encompass multiple

potential wares. On contrast, a ware is more spatially restricted and relates to a particular cultural setting, and probably overlaps with a more consistent tradition of pottery making. This consistency would be visible in a more restricted set of fabrics used by the potters. As discussed, it is likely that highly visible traits such as shape, colour and decorative patterns will form the most clearly identified element of these styles, but these will have been incorporated within thoroughly local *chaîne opératoires*. It can therefore be suggested that both the larger unit of Tell el-Yahudiya ‘ware’ (i.e. as the term is traditionally used), and the ‘Wadi Suq’ ceramic vessels are best seen as general styles, which include within them distinct local wares, each with their own local evolutionary trajectories. Petrographic and chemical analysis will be crucial to further pinpoint such wares to local locations of production.

7.2.3: A ‘horizon’ in ceramic evolutionary terms

Recently, Marco Iamoni (2014) has looked at ceramic transitions and ‘horizons’ in Bronze Age northern Syria. Although what constitutes a ceramic ‘horizon’ is not clearly defined in general (Iamoni 2014, 17), it indicates geographically widespread similarity of styles of forming and decorating a vessel, and may extend to the use of fabric groups of similar types. Such ceramic horizons go together with similar socio-cultural and economic conditions on a large geographical and temporal timescale. These can perhaps be seen to correspond to ‘conjunctures’ in a Braudelian sense (Bintliff 2004, 176; Braudel 1972). The word ‘horizon’ already implicitly refers to the dominant process of horizontal transmission explaining similarities in ceramic practices over a wider region, with continuity over many generations within local workshops adhering to more general ceramic fashions. Thus, the similarity in ceramic traits is based on widespread horizontal transmission; this takes the form of copying, between different more localized traditions.

7.2.4: Phylogenetic fidelity and the distinction between a horizon, style and a ware

Thus defined, we can also formulate future expectations to be tested in ceramic studies in general, on differences in phylogenetic signals relating to ‘styles’ and ‘wares’ and the nature of transmission of groups of ceramics. In this way, a weak phylogenetic signal, as encountered in our case-studies (low Retention Index, highly netted pattern) implies a large amount of homoplasy representing horizontal transmission in the form of borrowed traits and parallel developments, which makes it

likely that the vessels form part of a particular broader style, but actually relate to different local wares (sub-units within a broader tradition) representing distinct production within a set location. In the Syrian case discussed by Iamoni, this might be viewed as a response to the requirements of the MB-LB tributary economy. This can and should be further corroborated by petrographic and chemical analysis in future studies.

On a regional scale, if a strong phylogenetic signal is seen in the analysis (high Retention Index, clear branching pattern) this might suggest that the vessels are part of a tightly constrained production, showing vertical transmission within a unit of production, and can rightfully be called a ware. On the other hand, they might form part of a distinctive style which evolves through the transmission of ceramic practices in a hybrid environment through processes of horizontal transmission, transmitted between quite distinct groups of potters systematically borrowing traits, and guided by particular selective mechanisms. This is seen in the case of Tell el-Yahudiya ware piriform and biconical juglets (Chapter 4). The same can be argued for Wadi Suq spouted jars and beakers (Chapter 6). It then becomes necessary to target the way the knowledge was transmitted, and the particular selective mechanisms that drove a certain evolutionary pattern, to help us place the observed pattern within some kind of explanatory / archaeological narrative. We will discuss these narratives in more detail below. On an even large geographical scale (not attempted in this thesis), ceramic horizons can potentially show good patterns of ‘descent with modification’ within a *longue durée* perspective, as ‘transition’ can be seen as periods of gradual or more abrupt (punctuated) change evolving into a new ‘horizon’ as shared over a wide geographical area. A possible example would be juglet tradition, from the Early Bronze Age, through the Iron Age and into the Hellenistic and Roman period (with a move towards juglets in glass). These horizons will, however, always mask localized trajectories which will show their own evolutionary patterns based on descent from common local ancestors and the borrowing of traits from regional styles. Stated as such, phylogenetic results can be used to test the validity of archaeologically defined ‘styles’ and ‘wares’, when the results are related to processes of transmission and both temporal and geographical scale of analysis.

7.2.5: Is Tell el-Yahudiya ware falsely labelled a 'ware'?

The analysis of Tell el-Yahudiya juglets (Chapter 4) has brought forth the question of what actually constitutes such a 'ware' and whether this term is appropriate for the corpus of ceramic vessels studied. The phylogenetic analysis of Tell el-Yahudiya 'ware' helps us understand that it is not the entire corpus, but rather the larger production groups of Tell el-Yahudiya juglets that are best perceived as local 'wares', but which adhere to a more general style; they borrow traits which could spread easily due to their high visibility, and are mostly defined by elements of surface treatment and decoration that are easy to apply to pre-existing local techniques. This same highly visible decoration leads archaeologists to label all such individually as 'Tell el-Yahudiya ware' in ceramic reports, and draw thus conclusions about external (Egyptian contact). However, in many cases, individual vessels might actually be more similar to locally produced categories of juglet (which are not generally lumped with the Tell el-Yahudiya group) but are finished with either a red or black fired slip, depending on the degree of oxidization, and which may bear painted decoration or none at all. This implies that nuance is needed when discussing the meaning of the distribution of Tell el-Yahudiya vessels.

A case in point is the Tell el-Yahudiya type vessels found east of the Jordan, at sites such as Pella, Tell Hammam, Deir 'Alla, Amman and the Mount Nebo area, which are similar to the examples from the Der'a region of southern Syria (Bourke *et al.* 2006, 22, Fig. 15; 48: Fig 41, 49, Fig 42.1-2; Collins *et al.* 2015; van der Kooij 2006, 212: Fig. 9.6; Kaplan 1980, 289: Fig. 75b; Palumbo 1998, 107: Fig. 10.5; Maqdissi *et al.* 2002). These, according to their decorative patterns and shapes, were most likely produced in the southern Levant but adhere to a general style of decoration that employs dark surfaces and white incised lines (*contra* Bourke 2014, Bourke 2006, 49: for the examples from Pella suggested to be 'foreign' ceramics). A similar pattern is seen at Beth Shan, where locally-produced vessels are attested next to a single vessel that is of clear Egyptian origin on both stylistic and chemical grounds (Maier and Yellin 2007; Maier 2007, 290-291; Plate 10.19).

These vessels were likely incorporated within local usage by way of smaller gateway communities which would have filtered external influences and contacts through local potters and traders. This makes us question what actually constituted an 'Egyptian' object and how it was defined within local Levantine communities. As an

example, it is likely that Jericho in the Southern Jordan Valley which dominates the amount of ‘Tell el-Yahudiya ware’ juglets in this area (due to its extensive mortuary record) perhaps functioned as one of those smaller gateway communities. In fact the Tell el-Yahudiya juglets from (nearby) Tell Hamman, Deir ‘Alla and Amman resemble those juglets from Jericho quite closely, and one might wonder whether such juglets were still perceived as coastal or ‘Egyptian’ objects, or whether their meaning had been altered in the context of these local gateways. Perhaps they were not perceived as being purely ‘Egyptian’ but rather reflect a more hybrid identity of southern Palestine origin.

In a general sense, the Tell el-Yahudiya vessels only distinguish themselves from the wider class of juglets by some steps in production that fall relatively ‘late’ in the *chaîne opératoire*. These take the form of incised decoration, reduced firing and infilling with white paste. Thus ceramic traits are copied because local potters acquire knowledge through mechanisms of the trading and exchanging of these ceramic vessels, in addition to rarer shared ceramic practices over larger distances. As such the term ‘ware’ is more appropriate from a certain point in time only and in a strictly localized context when showing a clear integrity in the *chaîne opératoire*. Phylogenetic analysis corroborates this particularly strong development in production which is connected with cultural developments taking place at one of the key loci of production and use: Tell el-Dab’a. It is here that a phylogenetic signal is strongest among the juglets produced at least within the eastern Nile Delta, showing a consistency in terms of fabric, forming technique and finishing which constitute a ‘ware’. The ceramic evolution is thus best understood by placing it within the particular local developments at this site, with a strongly hybrid cultural trajectory (Aston and Bietak 2012; Bader 2013; Broodbank 2013; De Vreeze 2016a).

It would thus perhaps be more appropriate archaeologically to call the juglets produced in the eastern Delta from this period onwards (phase E/3) ‘Tell el-Dab’a ware’ within a general style of vessels which have a dark reduced surface and incised and lime filled decoration (§4.9.10). In contrast, ‘Tell el-Yahudiya’ ware as a ‘style’ encompasses many local wares produced, as already pointed out by Kaplan (1980) and re-emphasised recently by Aston and Bietak (2012), and confirmed by Cohen-Weinberger’s (2008) petrographic work on examples from sites in the southern Levant. However, related production of vessels continued in southern Palestine and

while this *could* be called a similar ‘style’ related to the ‘Dab’a ware’ it is actually more in line with local production techniques, thus forming separate wares. In reverse, cylindrical juglets with incised and infilled decoration are more likely to be an adoption of a novel shape from the Southern Levant into the local (Nile Delta) production of Tell el-Yahudiya style juglets (Aston and Bietak 2012).

7.2.7: Alternative trajectories with similar outcomes?

An important result of the analyses in this thesis is that they suggest that reasons for ceramic change can follow similar general patterns, but nevertheless are related to localized conditions, and even juxtaposing processes on a larger spatial and social scale. This brings back to the question how different archaeological narratives are created.

7.3: Part 2: the ceramic narrative

Let us return to the larger narrative set out in §1.1, where I compared the two evolutionary case studies as representing two sides of a balancing scale within the wider region. An important research question that I have asked in this thesis is whether an evolutionary approach, and more specifically, a phylogenetic approach, will allow us to question or even alter existing ceramic narratives. The previous sections suggest that in order to answer this question the temporal and spatial scales at which we want to set a narrative are important. If we now compare both case-studies, it seems that processes of social selection can have a similar effect set within quite different social and environmental developments. It is thus worth examining how this evolutionary approach integrates with the revised ceramic narratives in both case-studies. The fact that similar processes in ceramic evolution might be situated within different overall narratives is an important conclusion of this thesis, as it argues strongly against unilinear assumptions regarding the particular local reasons for ceramic change.

The case-studies show that ceramic evolutionary patterns can show similarities in terms of increased wheel production and selection against elaborate decorative patterns, but in periods of opposing socio-cultural developments; a period of increasing international trade and contact in the Eastern Mediterranean influencing the evolution of Tell el-Yahudiya juglets (chapter 4), compared to a period of cultural retrenchment and relative geographical isolation in south-east Arabia within the 2nd

millennium BC (chapter 5). In other words, the similarity in evolutionary patterns in both case-studies should be linked to *similar* technical responses to *different* larger scale social situations. To be more specific, these are based on similar technical limitations and possibilities in the case of the potters on the one hand, and social processes most strongly connected to the formation of group identity on the other. In this way, they seem to form overlapping themes which are repeated throughout material cultural development, but which can be placed within different cultural historical settings.

7.3.1: The funerary and feasting niche

A theme which is common to both case-studies and crucial in understanding evolutionary trajectories is the predominant, but not exclusive, use of the ceramic vessels of interest in funerary contexts. Although patterns of archaeological retrieval play a role, it is clear from the present evidence that this particular social context of the use of ceramics is critical in both case-studies. It can be said that both for the Tell el-Yahudiya juglets and Wadi Suq spouted jars and beakers, a particular ‘niche’ existed associated with the performance of funerary rites and feasting in general. Insights on ‘niche construction’ have been borrowed from evolutionary theory in recent cultural studies and these indicate that human behaviour can create its own evolutionary momentum and trajectory due to the construction of cultural niches in its environment (Laland and O’Brien 2010) (§2.2.3). On the basis of the case-studies, and comparative ceramic studies, there might thus be such a general tendency, discernible in ceramic evolution, once a particular group of vessels is strongly connected with a particular cultural process such as funerals or feasting (a cultural niche).

The predominance of funerary deposits as the origin for the ceramics studied herein might point to such a development, with this funerary or feasting ‘niche’ imposing its own dynamic on the evolution of the ceramic vessels. Although in both cases, the ceramic types are known from domestic contexts as well, they clearly dominate in funerary deposits—although this might partially be connected to preservation—and may be particularly strongly associated with feasting and ritual display surrounding funerary rites, crucial as a driving factor in the evolution of these ceramic vessels. It would not be wide of the mark to state that it is a general principle for decorated ceramics in the Near East – if not other cultures as well – since their

inception, to be associated with consumption and display, and thus forming a recognizable historical pattern. To cite but two Near Eastern examples, decorated Halaf and Ubaid ceramics of the Neolithic, were geared towards display and feasting (Campbell 2008; Nieuwenhuysen 2007; 2008), while a similar causal connection is seen in the use of so-called ‘Philistine’ table ware in the Iron Age southern Levant. Interestingly the latter has also been assigned a role in terms of defining ‘ethnicity’ (Bunimovitz and Faust 2001; Mazov 2005). Signalling its more universal application as a framework, the same has been argued in European archaeology, for instance within the Neolithic with the introduction of ceramic practices in the Ertebølle culture (Fischer 2002; Polvén 2013).

Recently O’Conner (2015) has argued that feasting not only aids in stressing communal ties, but also makes distinctions more clear, between those who ‘have and have not’ in terms of social and economic power. I would argue that in both case-studies, the ceramic vessels became a key element in stressing such unity. In the case of Tell el-Yahudiya ware this could perhaps also be seen to relate to what has been suggested by Janet Richards (2005: 179) as a growth of a ‘middle class’ and their funerary rites within the Middle Kingdom. For the urban giant (max. 250 ha) of Tell el-Dab’a, it is not hard to imagine the drastic increase in such a ‘middle class’ of minor officials, traders, and craftsmen with different backgrounds, due to the crucial gateway position of the site within the Middle Bronze Age trade-network (Bietak 2010a).

However, in the case of Wadi Suq period a different social dynamic was likely at work, within a less urbanized, less international sphere. Here, there were no large urban agglomerations comparable to Tell el-Dab’a or Mesopotamian sites such as Ur. The largest settlement known for the period is perhaps around 4 ha; thus a ratio of 60 times smaller than Tell el-Dab’a (Magee *et al.* 2015, 4)!³² The related difference in the number of people surely reflected on the size and diversity of the economic output, and breadth of skill available. Within these smaller south-east Arabian settlements and scattered communities, the distinctive ceramics might have been used in collective gatherings; being strongly but not exclusively structured around funerary monuments, and could very well involve tribal alliances (De Vreeze 2016b). The

³² Though significantly, less intense activity has been documented in surveys and test trenches in an area extending almost 630 ha around the site (Magee 2015, 6).

Wadi Suq spouted jars and beakers seem to be part of a movement at the start of the 2nd millennium BC aiding the restructuring – or perhaps we should say *reconstruction* – of social ties within a region which was perhaps retrenching from earlier interregional contacts and recovering from some form of social upheaval at the end of the Umm an-Nar period. These social ties were probably strongly tribally organized (Cleuziou 2003; Magee 2014), but it is likely that decorative motifs painted on the jars, beakers and cups were also recognized in terms of regional ties, although the exact role of these regional distinctions in social interaction have to be further studied in terms of distribution and existing social theory (Braun and Plog 1982; Plog 1980). Some motifs occurring on vessels from Qarn al-Harf only show good parallels at nearby cemeteries such as Shimal and Dhayah, suggesting a regional focus in some ceramic traits which might have conveyed messages regarding local identities.

Thus, following O'Connor, we argue that both feasting and ceramic decoration worked to unify communal gatherings on a scale larger than that of typical settlements, but might also have played out power relations within the local setting of these gatherings. General patterns might thus be seen in the evolution of ceramic vessels which are used in such 'social niches' as feasting and funerary rites (§2.2.3). The two case studies on Tell el-Yahudiya juglets and Wadi Suq ceramics can be used to focus on this particular theme in order to observe commonalities. This principle has been argued for in detail by Spielmann (1998; 2002).

7.3.2: Tell el-Yahudiya, The Hyksos and a false narrative?

As previously mentioned (§1.2.2 and Chapter 4), Tell el-Yahudiya juglets have been intrinsically linked to the 'Second Intermediate Period' in Egypt, and the so-called 'Hyksos' rule in the Egyptian Delta (Kaplan 1980; Bietak 2010a). However, ongoing critique has been directed at the chronological scheme used at Dab'a which has been showing cracks for years due to advances in absolute dating in the Eastern Mediterranean (Bietak 2013; Höflmayer 2015; Kutschera *et al.* 2012; Manning 2014). As suggested recently by Höflmayer (2015: 285), the datum-lines used for the Tell el-Dab'a chronology are problematic, as the phasing of Dab'a has been constructed upon four datum-lines (§4.3.5). It is these four fundamental pillars of the traditional Dab'a chronology, supporting the whole stratigraphic system at the site, which might be ultimately weak, thus leaving the chronological structure in need of major readjustment. Thus, it is important that while the phylogenetic studies of Tell el-

Yahudiya juglets appear to broadly support the relative seriation of Tell el-Yahudiya ware as proposed by the Dab'a team in recent syntheses (Aston and Bietak 2012; Bietak 2013), caution is warranted in seeking to connect this development to socio-political developments such as 'Hyksos' rule on the basis of the existing relative chronology, as this might ultimately prove to have been wrong.

In practice, if we accept the radiocarbon dates which push the phasing back around 100-120 years (~ 120 years), it is clear that the acceptance of Tell el-Yahudiya juglets produced in the Northern Levant at the Delta settlement of Dab'a goes right back to the start of the Middle Bronze Age, at a time when the region formed part of Middle Kingdom Egypt (the starting date of Dab'a phase G/4 dated should be dated around 1900 cal BC according to C14 dates: Kutschera *et al.* 2012, 417: Fig. 6b). The subsequent developments of Tell el-Yahudiya juglets in the eastern Delta; best attested at Dab'a, and the proposed punctuated equilibrium in production in phase E/3-E/2 would then take place *before* the height of the Hyksos rule over the Delta, which is dated traditionally around 1650 BC (§4.3.4). This change would ultimately entail a revision in the existing narrative, and means that we can now a) link the development to local processes visible in the archaeological data, and b) see them in the light of a *longue durée* process of 'hybridization' in the eastern Nile Delta, of which Tell el-Dab'a is the largest exponent in terms of settlement size, and in which Tell el-Yahudiya ware is just one instance (Broodbank 2013, 360-361; De Vreeze 2016a).

As this thesis has hopefully demonstrated, the importance of phylogenetic analyses is that they can help analyse material cultural evolution and form an independent check on relative chronologies on the basis of an internal logic within the ceramic data: descent with modification of technical traits from a common ancestor. However, this does not take away from the fact that these results are in need of independent absolute dating in order to ground (or root) the phylogenetic trees and prune the branches.

7.3.3: Wadi Suq collective burial, consumption and group alliance

Around the same time in south-east Arabia, a different development took place. Here, ceramic evolution can be connected to regionalization, and possible retrenchment from the more cross-cultural connections of the previous millennium (§1.1.3). As

suggested, environmental degradation (4.2 kyr BP event) might play a role in the cultural developments within south-east Arabia and the evolution of ceramics. However, this is likely not as a direct selective force but rather mediated through social decisions and adaptations to new cultural and environmental conditions such as a decrease in settlement intensity, and migration to areas less affected by environmental change. For instance, the lack of wood for fuel has been suggested as a reason for ceramic change (Carter 1997a, 224). Nevertheless, not only environmental change but the extensive use of fuel for the copper producing industries of the Bronze Age could have been instrumental in making it a critical source in the region already under climatic stress (Weeks 2003). For the beakers and cups used in the phylogenetic analysis, and showing the clearest evolutionary trajectory, the regional distribution of the types may hint at a chronological pattern where there is a retrenchment to the Northern Emirates, though this is in need of further exploration including more detailed provenance studies.

7.3.5: Evolution, chronology and regionalization in the Wadi Suq period

So far, the Wadi Suq ceramic traditions have not been studied in great enough detail to really get to grips with different technical skills portrayed regionally. However, the phylogenetic study of the ceramics does hint at different regional trajectories. These can perhaps partially be interpreted as chronological, with the northern Emirates showing higher rate of continuity. However, with the lack of absolute dates from well stratified contexts and the general lack of habitation sites and paucity of sites in certain regions, this picture needs further elaboration.

What is clear is that in a wider regional sense, the Wadi Suq material culture shows a period of increasing entrenchment, or ‘niche construction’ focussing on the northern Emirates with the scaling down of 3rd millennium interregional connections. This is not only attested in the ceramics but also in terms of tomb architecture, and a similar pattern is suggested by the evolution of the animal pendants, although new finds in other areas of south-east Arabia could alter this perception (§5.7).

Concluding, the use of specifically drinking ware such as spouted jars and cups must have functioned as an integral part of social life and the strengthening of social bonds (Bray 2003; Dietler 2006; Joffe 1998; Pollock 2003; Sherratt 1995). Until more detailed petrographic/chemical research is undertaken we will not really know if

ceramic vessels were widely distributed between communities within south-east Arabia, although this is strongly suggested by the similarity in shapes and decoration. As suggested earlier, such clearly visible characteristics of the ceramics might have easily spread within a highly mobile society, with larger meetings organized around seasonal festivities, the construction of tombs and interment of the dead. It is very likely that novel features in decoration which developed in a particular community were spread towards other pottery producing communities due to such communal gatherings. On the other hand, certain decorative motifs seem to be highly local and might have functioned to signal particular groups, or particular tribal alliances (Braun and Plog 1982; Carter 1997a, 244). The mobility and interchange of these ceramic features should form an important avenue of future research as they can ultimately lead to a better understanding of the difference in the construction of social ties within prehistoric societies of south-east Arabia.

7.4: Part 3: Ceramic data and phylogenetic challenges

Applying phylogenetic methods to ceramic data poses challenges, not only for our present case-studies, but for the archaeological discipline in general. I suggest these challenges involve both issues with the methodology, and with the archaeological material and the way we record it. Hence, it is useful to reflect in some more detail here on those issues that can help us to see how we might in future incorporate phylogenetic methods in ceramic studies.

While this thesis is meant to show the possibilities of the approach, it also seeks to point out the lacunae in our data that result from current practices in describing and publishing ceramic evidence. Hence, a number of issues have come forth when dealing with the data collection for this thesis and trying to code the data to be used for phylogenetic analysis. These have implications for general ceramic studies. I will consider some of the major themes and issues in turn, although not necessarily in order of importance. Problems faced when trying to apply phylogenetic methods are:

- 1) Absence of ceramic data and the often incomplete dataset for ceramics due to fragmentation and post-processual processes (i.e. the nature of sherd material).
- 2) Visibility and recognition of the particular *chaîne opératoire* (see above §7.1.1).

- 3) When ceramic data is fragmented, its typology often relies heavily on decoration; this is theoretically one of the elements more predisposed towards horizontal transmission between communities and less attached to a fixed local *chaîne opératoire*.
- 4) Absence of good provenance data required to locate units of production.
- 5) The methodological constraints of phylogenetic approaches.
- 6) Assumptions about the relationship between behavioural variability and artefact variability (Schillinger *et al.* 2016).

7.4.1: Fragmentary data and absent data

Fragmentary ceramic data, which is especially seen in the second Wadi Suq case study, yields problems in finding adequate taxa and characters for coding in phylogenetic studies. This has not only been a challenge in this thesis but forms a wider issue in applying phylogenetic methods to ceramic data, or other artefacts in fragmentary state. Ethan Cochrane has used phylogenetic methods to study the transmission of ceramic traits in Lapita Pottery (Cochrane 2009a; 2013; Cochrane and Lipo 2010). His analyses include information on rim-sherds and decoration. Although he should be lauded for trying to use fragmented data for phylogenetic analysis, there are issues with his approach. For instance, it leads to the necessity to study characteristics such as rim shape and decorative characters separately, and because he could not analyse them within a single dataset, the full interplay between morphological characters and decorative (stylistic) characters could not be examined and the potential differences within a ceramic type explored. For instance, his cladistic analysis of rim types is based on 5 character traits, 4 of which relate to features of the rim-shape and 1 character relating to the predominant temper (Cochrane 2009a, 116; 118: Table 6.1). A subsequent article suggests that phylogenetic analysis of Lapita decoration does not show a branching pattern (Cochrane and Lipo 2010). The data in this thesis suggests that the ceramic decoration of a particular class of vessels might indeed show differences in phylogenetic consistency compared to characters in forming the vessel, and ideally both types of information must be taken into account when coding the data.

7.4.2: The evolution of ceramic decoration

A central question which calls for a broader review and has more wide-ranging implications is: why does decoration decline in certain periods? This question has

been addressed for the Late Neolithic period for example (Campbell 2008; Wengrow 2001), but there are parallel situations in, for instance, the Late Bronze Age Levant (Franken and London 1995), and in Iron Age Late Philistine ware (Ben-Shlomo *et al.* 2009). The waxing and waning of decorative motifs in fact provide the key ‘cultural anchors’ for many ceramic chronologies. These fluctuating processes are crucial in other methods of quantification such as seriation (Lipo 2015).

For instance, at the end of the Ubaid period, not only does painted decoration on pottery disappear ‘almost entirely’, as Campbell (2008: 57) suggests: “It is not simply that the proportion of decorated vessels declines. The amount of decoration and the variety of motifs also decline at the same time.” This same pattern can be attested in Tell el-Yahudiya ware and Wadi Suq vessels (though in the latter case more detailed chronological information might be necessary), where a clear evolutionary pattern shows that the variety of decoration declines. This decline is attributed to several factors of which perhaps each on its own would not yield such an effect. However, when these combine they form a powerful mechanism which leads to the regression in decoration, something that we might suspect to be culturally repetitive. It would be interesting to test this mechanism for a wider number of artefact case studies within a wider archaeological context.

For our case studies we might suggest that the decline in decorative complexity is attributable to a combination of factors, which lead to patterns of cultural transmission by the potters in the region. An important cultural factor is related to the establishment of a ceramic ‘niche’ for these vessels in feasting and funerary rites. I suggest that, initially, the elaborate decoration of such vessels lead them to become popular in this kind of social communal display. Yet after these vessels were culturally established, such elaborate decoration was less necessary to signal this role, as the vessels became an integral part of the cultural package surrounding these activities. Subsequently, potters responded to selective pressure against elaborate decoration based on a number of factors. Crucial is the use of the wheel to form vessels (it can give crucial momentum to a decline in decoration). As the case-studies of Tell el-Yahudiya and Wadi Suq vessels suggest, this pattern can be set against a background of different, or even opposing, environmental and cultural processes, and as a general principle could be tested in other archaeological historical settings.

7.4.3: Where evolutionary studies dare not venture (yet)?

An area where phylogenetic methods and evolutionary approaches might be seen to have fallen short so far, but addressed in more detail in this thesis, can be related to the cultural meaning of stylistic change (refer to §4.13.1; 7.3.1 above). The role of decoration in society in communicating ideas and social ties is important but does not immediately come forth as a ‘functional’ aspect in evolutionary approaches (§2.4.1-2). This shortcoming could for instance be countered by incorporating more recent insight on agent-object relations as analysed within social network theory (see §7.5.2 below).

7.4.4: Assumptions about the relationship between behavioural variability and artefact variability

Another more general concern is that by applying phylogenetic methods, we assume that the characters we define show some sort of ‘heritability’ and ‘descent with modification from a common ancestor’ related directly to past human behaviour. In fact, the character trait might be based on other processes (see now: Lycett and Cramon-Traubadel 2015, for a discussion of lithic data; Schillinger *et al.* 2016). A similar concern could be raised about ceramic characters such as the measurements of a vessel, perhaps relating to factors such as the size of the wheel and the character of the clay and temper. The decline of decoration could similarly be seen to relate to different factors (role of the wheel, lack of material and technique). However, as hopefully shown in this thesis, when we establish a link between the potters’ action and response to these conditions by focussing on characters which are seen to correspond to steps in the *chaîne opératoire*, we can evaluate these different factors within their archaeological context.

7.5: Future prospects

7.5.1: Integration of phylogenetics and the *chaîne opératoire* approach

Discussing the potentials and problems opens up the way to consider future prospects. A challenge to current ceramic typological studies, when these are undertaken on a regional scale, and thus compare assemblages from different sites lies in their predisposition to focus upon horizontally transmitted, mostly ‘stylistic’ features. This is partly due to the higher visibility (what is deemed diagnostic) of such traits - one of the main reasons for them being more easily transmitted over a wider geographic area.

However, as the case-studies show, decoration might be seen as a very flexible characteristic which can easily be shared between distinct *local* traditions of producing ceramics. Additional evidence on the spread of production techniques remains hard to grasp and needs a more in depth knowledge of the *chaîne opératoire* combined with less visible characteristics such as clay and temper preparation.

The current analyses have shown that it is crucial to obtain as much information on the full *chaîne opératoire* as possible. General stylistic studies of ceramics do not really suffice as they conflate processes of ceramic change and transmission of ceramic practices, as for instance seen in relation to Tell el-Yahudiya ‘ware’ (§4.2; 7.2.5). Additionally, phylogenetic approaches should be further integrated with experimental studies designed to clarify and understand the *chaîne opératoire*, including testing of the method on the basis of directly observed behaviour of present-day or ethnographically documented potters. It suggests the high importance of acquiring a more detailed, full coverage of the *chaîne opératoire* of particular ceramic classes using a wider range of techniques, from clay and temper selection (to the microscopic level) to firing. This data could be coded in terms of individual decisions in such a way that phylogenetic methods can be used to trace evolutionary developments. This should preferably be a targeted study of key ceramic assemblages related to local production units. Tracing the origin of the production to particular regions or sites is crucial. A more integrated methodology making use of petrographic analysis and chemical identification of production areas is thus needed in both regions addressed in this thesis, and particularly in south-east Arabia.

7.5.2: Evolution of artefacts and social exchange networks

A good avenue for future studies would be to further integrate phylogenetic methods with the use of network approaches, which have become popular in archaeological analysis in terms of ‘formal network analysis’ (Knappett 2013; Mizoguchi 2013; Leidwanger *et al.* 2014; Hodder and Mol 2016). Combining methods of formal network analysis with phylogenetic methods could add powerful explanatory mechanisms of evolutionary theory to unravel some of the perceived ‘entanglement’ in agent-object relations. Moreover, both approaches could be integrated further using geographical information systems (GIS) to improve our understanding of the role of the physical landscape, land routes, and seaways; i.e. which can function as ‘Transmission Isolating Mechanisms’ (TRIMS) or

Transmission versus ‘Transmission Aiding Systems’ depending on technological developments in society. Unifying these existing approaches to include evolutionary approaches within archaeology and the social sciences in general would give us powerful new ways of untangling some of the intricate interplay between landscapes, people and artefacts.

Appendices Thesis

Chapter 4: Tell el-Yahudiya Ware

- 1) Character list and phylogenetic coding case study 1
- 2) Character list and phylogenetic coding case study 2
- 3) Character list and phylogenetic coding case study 3
- 4) Jericho tombs Tell el-Yahudiya vs. non-Tell el-Yahudiya juglets

Chapter 5: Wadi Suq

- 1) C-14 list
- 2) WS pendants taxa; character list and phylogenetic coding

Chapter 6: Wadi Suq ceramics

- 1) WS Spouted jar character list and phylogenetic coding
- 2) WS Beakers and cups character list and general coding
- 3) WS Beakers and cups character list and phylogenetic coding

Appendix 1: Character list case study 1

All the characters are binary: 0 = absent, 1 = present.

Morphology: techniques of shaping the vessel

Overall shape (characters 1-5)

1) ovoid, 2) piriform, 3) biconical, 4) globular, 5) cylindrical.

Rim shape (characters 6-12)

The following characters (6-12) have to do with the distinct rim shapes. These rim shapes can be defined as follows:

6) 'Candlestick rim' is a rim type involving folding of the rim with a thickened fold halfway the rim, and a folded lip, 7) everted rim with an internal cutter, this rim type is 8) kettle rim: a rim that curves outside from the neck and then curves inside creating a gutter, 9) straight (direct) rim, a rim that is almost vertical and has no sharp fold to the outside or inside, 10) everted rim: a rim that has the lip folded outside, 11) cut-away spout: a rim that has a pinched triangular opening to facilitate pouring, 12) rolled rim: a rim with everted lip that is rolled over thus creating a thickening.

Handle shape (characters 13-16)

13) Triple stranded handle: handle made from three coils of clay pressed together 14) Double stranded handle: handle made from two joined coils of clay, 15) Single strap handle: handle formed by a single coil of clay, 16) push-through handle: handle that is distinctively pushed through the body of the vessel.

Base shape (characters 17-24)

17) 'Offset' flat base. A base that has a slight offset angle and a flat surface. The flat rounded surface is probably not separately worked and indicates the vessel was made from the bottom up, 18) ring base: a base that is made by adding a separate ring to the bottom of the vessel. The ring can either be formed from the remaining clay at the thicker base, or more likely by adding a separate coil that is formed into the ring-base, 19) 'off-set' disc base: a base that is formed by an extra clay disc added or moulded to the base, it has a more pronounced thickness to the flat base, 20) disc base: a base formed by an additionally added layer of clay formed in a disc shape

which is more pronounced to character 20, it can be formed from the excess clay when finished upside down, **21**) button base: a base with a marked outstanding clay knob that shows a distinguished profile, it can be formed out of the excess clay of the base when finished upside down, **22**) pointed base: a base that is finished into a point and smoothed as such with no extra plastic features, **23**) rounded base: a base that is rounded in shape and formed by closing the vessel and smoothing the base, **24**) a flat base that has no extra moulding of the clay but is formed by closing the bottom and smoothing the vessel.

Decoration

Decoration bordering (characters 25-27)

25) lines incised at the neck: lines that are incised with a sharp implement at the neck of the vessel before firing, often on the wheel, **26**) lines incised at the base: lines incised with a sharp implement at the base of the vessel, likely when the vessel is on the wheel, **27**) decoration without delimiting incised lines: the vessel is decorated but has no lines defining the decorated areas.

Decorative scheme (characters 28-30)

28) 3 or more horizontal frames separated by reserved lines: the vessel has three or more horizontally demarcated frames in which the decorative motifs are placed, **29**) 2 horizontal frames: decoration is placed within two demarcated frames, **30**) vertical frames: decoration is placed within vertically orientated frames.

Incisions in reserved bands (characters 31-32)

31) wavy lines/ concentric waves: incised wavy lines or concentric waves inside the reserved bands that are not filled with indented motifs, **32**) concentric circles in reserved bands: incised concentric circles with different diameters incised in the reserved band.

Decorative patterns (characters 33-41)

33) Floral and Faunal motifs: decorative motifs consisting of floral motifs (stylised palms or lotus flowers/lilies and faunal motifs: mostly water birds, **34**) Double delineated triangles: triangular motifs with double incised delineation and filled with

indentions, **35)** Standing and pending triangle in single frame intertwining: standing and pending triangular motifs incised and filled with indentions within a single framed, **36)** standing and pendant triangles points attached: Incised standing and pendent triangles with their points attached (in fact realised by incising two crossing diagonal lines) filled with indentions, **37)** standing triangles: incised triangles pointing towards top vessel filled with indentions, **38)** pending triangles: incised triangles pointing towards the base filled with indentions, **39)** triangle triple incised line: triangles with defined by triple incised lines not filled by indentions, **40)** rectangles: incised rectangles filled with indentions (interspersed with rectangles that are burnished, **41)** zigzag band: incised zig-zag band filled with indentions.

Decorative techniques of impressions (characters 42-45)

42) bands filled with herringbone and zigzag combing: filling created by comb impressions impressed in with alternating angles creating a V shape (herringbone) or in a zigzag pattern, **43)** bands filled with horizontal or diagonal combing: impressed decoration with comb in a single orientation, either diagonally or horizontal in regards to the vessel standing upright, **44)** deeply comb impressed bands: comb decoration applied by pressing the combs deeply into a banded zone creating the leather hard wall of the vessel to indent, **45)** comb incised grooves: decoration is not by short sequential indentions of the comb but by incising grooves with the comb on the vessel: oft while it is still on the wheel.

Matrix_TeyGENERALGROUPS

'A'	110001111000110010000000110101000000010001100
'B'	110001001100110010000100100100000000110100100
'C'	111000000101110000101000100110010000000000100
'D1'	10000000010001000010000000001000000000001000
'D2-4'	01000000100111100111100000001000000000001100
'D5'	00100101010101000111100000101000000000001100
'D6'	00001000010101100000001100101000000000001100
'E2-3'	100000010000100000011000000100100001010000000
'F'	010000011001010001001001110110000000000100000
'G'	010000011001000001000000000110000001000000100
'H'	010001000000100000000000110100001000110100000
'T'	110001010001111001101000110110101111110110100
'J'	010001010101011001001000110110101000110000000
'L1'	010001000001001001011000001001000000000001100
'L2-8'	001000000001001001011010001010000000110001100
'L9'	000100000001001000000010001011000000110001100
'L10'	00010000000100100000001000100100000000000010
'L11-12'	000010000001001001000010001011000000100001100
'L13'	01111000000100100101001000100000000000000001
'N'	000100011110011100000010100110000110111010100

Appendix 2: Character list case study 2

Characters:

Subsets

Manufacturing technique

CHAR 1:

1) Handmade (without help fast wheel), 2) wheel made (with help fast wheel)

Almost impossible to make a distinction between wheel making and wheel-throwing, although in many cases wheel-throwing may be assumed.

Morphological

CHAR 2: Body shape (excluding open forms and zoomorphic vessels):

- 1) ovoid (rounded body, fairly large vessels)
- 2) piriform (pear shaped, different in angle from widest point to shoulder and widest point to lower body)
- 3) biconical (nearly similar angles from widest point up and down),
- 4) cylindrical (cylindrical body with widest points at extremities of the vessel),
- 5) globular (rounded body of limited height with gentle curves),
- 6) quadrilobal (rounded body with deep vertical lobes)

CHAR 3: Rim shape:

1) stepped rim (with gutter) 2) stepped rim, 3) inverted ('candlestick rim', 4) inverted vertical stance, 5) everted hollow, 6) everted, 7) everted pinched, 8) everted folded, 9) pinched spout

CHAR 4: Handle form:

- 1) triple stranded in a row, 2) triple stranded 1 on top of two, 3) double stranded (rounded coils), 4) double stranded (flattened/square coils), 5) single strand (rounded), 6) single strand (flattened-oval section).

CHAR 5: handle pushed through the body (Cypriote style)

YES/NO = 1 or 0

CHAR 6: small clay button on transition between handle and rim (Jericho/SL style)

YES/NO = 1 or 0

CHAR 7: Base form:

1) ring base 2) solid ring base around pointed base (technical feature at Dab'a, ring base too high!) 3) thin button base (round section) 4) button base with rounded section which is protruding 5) button base with pointed end, 6) button base with angular section, 7) Flat disc base 8) no added feature to base (either pointed, flat or rounded = otherwise an overlap with morphological character coding, loss of independence character!)

2) *Lay-out of decoration*

CHAR 8: Panel and reserved band lay out.

Horizontal lay-out

0) vertical lay-out, 1) 5 panels divided by reserved bands (2 panels in the middle attached), 2= b) 4 panels divided by reserved bands, 3 = c) 3 panels divided by reserved bands, 4 = d) 3 panels, 2 attached, 1 reserved band, 5 = e) 2 panels, 1 reserved band in the middle, 6 = f) 2 thin decorative bands, panels reserved, 7 = g) 1 thin decorative band, panels reserved, 8 = h) no division, decoration horizontally applied.

CHAR 9:

Vertical lay-out

At Dab'a this information is recorded in more detail. The vessels from Kaplan may simply be stated as vertical segments (character state ?)

0 = horizontal lay-out, 1) 8 segments, 2) 5 segments, 3) 4 segments, 4) 3 segments 5) 2 segments

CHAR 10: Presence of incised lines near the neck:

2) multiple incised lines, 1) single incised line, 0) no incised lines.

Multiple incised lines at the neck marking the transition between neck and body.

CHAR 11: Presence of incised lines near the bottom:

2) multiple incised lines, 1) single incised line, 0) no incised lines.

3) *Motifs of decoration*

Horizontal orientation of panels

CHAR 12:

Bands filled with comb impressions = YES/NO = 1 or 0

Flora and fauna

CHAR 13:

Floral motifs – lotuses and palm trees = YES/NO = 1 or 0

Faunal motifs

CHAR 14:

Birds = YES/NO = 1 or 0

CHAR 15:

Fish = YES/NO = 1 or 0

CHAR 16:

Feather/Rishi pattern = 1 or 0

Strict Geometrical motifs

CHAR 17:

Rectangles and squares (squares filled with comb impression, two rectangles without comb impressions) = YES/NO = 1 or 0

CHAR 18:

Triangular motifs (general character state) = YES/NO = 1 or 0

CHAR 19:

Standing triangles (pointing upwards) = YES/NO = 1 or 0

CHAR 20:

Pending triangles (pointing downwards) = YES/NO = 1 or 0

CHAR 21:

Triple incised triangles (Cypriote, Dab'sa Toumba tou Skourou connection) = YES/NO = 1 or 0

CHAR 22:

X shaped incisions resulting in triangles touching at the point = YES/NO = 1 or 0

CHAR 23:

Triangles interlocking (triangle 1 pointing towards widest point triangle 2) = YES/NO = 1 or 0

CHAR 24:

Bands running in zigzag way between the panel YES/NO = 1 or 0

CHAR 25:

Geometrical motifs in free range form in a diagonally oriented position (Cypriote influence) = YES/NO = 0 or 1

CHAR 26:

Are the reserved bands and decorative elements framed by incised lines or not = YES/NO = 1 or 0

CHAR 27: Reserved bands:

1) burnished, 2), burnished, filled with wavy incisions (semicircular wavy pattern 3) burnished, filled with line incisions 4) unburnished/ left untreated.

4) Techniques used for decoration

CHAR 28: Type of tool/number of teeth on comb (hard to classify)

Kaplan uses

1) 1 point, 2) 2 teeth, 3) 3-7 teeth, 4) 8-10 teeth, 5) 10+ teeth

CHAR 29: Directionality of comb impressions:

1) incised decorative lines 2) comb filling of decorative elements, 3) vertical row of impressions, 4) horizontal row of impressions 5) diagonal comb impressions, 6) 'herringbone' motif (triangular motif), 7) zigzag comb impression 8) comb impressions without predominant orientation (may be a combination between zig-zag, diagonal and 'herringbone'), 9) bands filled with incised lines (Levantine feature!) 10) combing of the surface (not comb incisions but lines by drawing the comb over the clay body).

5) Firing attribute

The rough indication of colour is problematic since it is a continuous feature and it is the result of individual firing conditions that relate to traditions but also the local circumstances. Yet in general there is a development from reddish/brown fired vessels at the start to dark fired vessels at later stages (reduced firing is an important feature of the chaîne opératoire).

CHAR 30:

1) Reddish (Munsell ---) (oxidized) = RPI

2) Brownish (Munsell ---) (partly oxidized-neutral firing) = BPI

3) Black-gray (Munsell ----) (reduced firing) = SPI

CHAR 31: Filling with calcium paste = YES/NO = 1 or 0

Actual infilling with white paste = often taken for granted. Not specifically mentioned! It is possible that not all juglets incised/combed decoration was filled with paste!

CHAR 32: Clay source: might be a character that actually counts in the cladistics analysis, or a character to model on the tree.

- 1) IV = non-local (IV-2-a (non-local), IV-2-b (non-local), IV-2-c (non-local) and IV-
- 12) I-d and I-b-2 = local or at least Nile clay

Matrix_Dabapiribi

Afula_1	2123007012200000000000000113320?
Afula_2	2113007302210000010100000113220?
Afula_3	2113007302210000000000000113220?
B4nr8	22230041000100000000000001145211
B4nr7	22230041000100000000000001145211
I1.5	22430012022000001111000001112212
I2.2anr27	22430013022000001111000001142211
I2.2anr28	22630014022000001111000001112211
I2.2anr29	22330013021000001111000001112211
I3.1c	2330015022000000111000001142311
I3.2anr53	22660065022000000111000001132312
I3.2anr43	22330065022000000111000001142312
I5.3b	22630043020000000101001001142312
I6.2nr77	226300150021000001110010011?2211
I6.2nr76	226300150001000001110000011?2212
J1.4	22660055020011010000000001112312
J1.7a	2273004800001000000000000111312
J1.7b	2273005800001100000000000111312
L1.3b	22660010300000000000000001146312
L1.3c	22660010400000000000000001146312
L1.3cvar	22660020400000000000000001157312
L1.4b	22660040400000000000000001157312

L1.5a	22660060300000000000000000001146312
L1.5b	22660060400000000000000000001156312
L12.2a	2386008800000000000000000000146312
L13.2	236600120000000000000000000011?8102
L14.2	22660050400000000000000000001147312
L2.3	236600150000000000111000001152312
L2.4b	2366004500000000001110000011?2312
L2.5b	23660015002000000111000001142312
L4.1	236600150000000000111000001152312
L5.3a	23660012000000000000000000001156312
L5.3c	2386001201100000000000000001155312
L5.4	23660045000000000000000000001156312
L6.1b	23660015000000000000000000001156312

Appendix 3: Character list case study 3

CHAR 1: Fabrication technique

Handmade 1) formed by hand, either by coiling or using a moulding surface. The juglets show traces of joining the separate parts of the walls with slight overlap.

wheel-made 2) juglets turned on the wheel.

CHAR 2: size

Overall size of the vessel expressed in length and width. Two groups are distinguished:

- 1) Length smaller than 7 cm and width smaller than 5 cm.
- 2) Length 7-13 cm and width 5-9 cm.

CHAR: 3

Mouth of the vessel:

- 1) Trefoil (pinched lip by pressing the end with two fingers.
- 2) 'kettle rim' a rim that is folded slightly outward and then the rim is folded inside (maybe using a tool such as a stick). The lip can be folded inwards to different extents.
- 3) Everted folded. The rim is everted and the lip is folded over creating a thickened ending.
- 4) The rim is virtually upright and can have a slightly thickened lip.

CHAR 4:

The handle

- 1) Double stranded using two adjoined rounded coils.
- 2) Double stranded with flattened coils more square in section.
- 3) Single stranded handle with a pinched in depression.
- 4) Single stranded handle, either oval or rounded in shape.



CHAR: 5

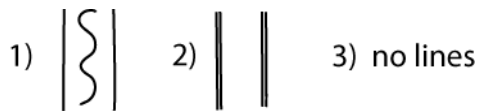
‘Push-through’ handle.

The handle is pushed through a hole made in the vessel (by inserting a finger or stick) and fastened in this way. It is a typical Cypriote feature. Either absent (0) or present (1)

**CHAR: 6**

Lines underneath the handle created by a pointed tool.

- 1) Vertically delineated lines with a wavy line in the middle.
- 2) Double or single vertically delineated lines.
- 3) No lines incised vertically below the handle.

**CHAR: 7**

Lines incised at the transition between the neck and the body of the vessel.

0 = absent, 1 = present.

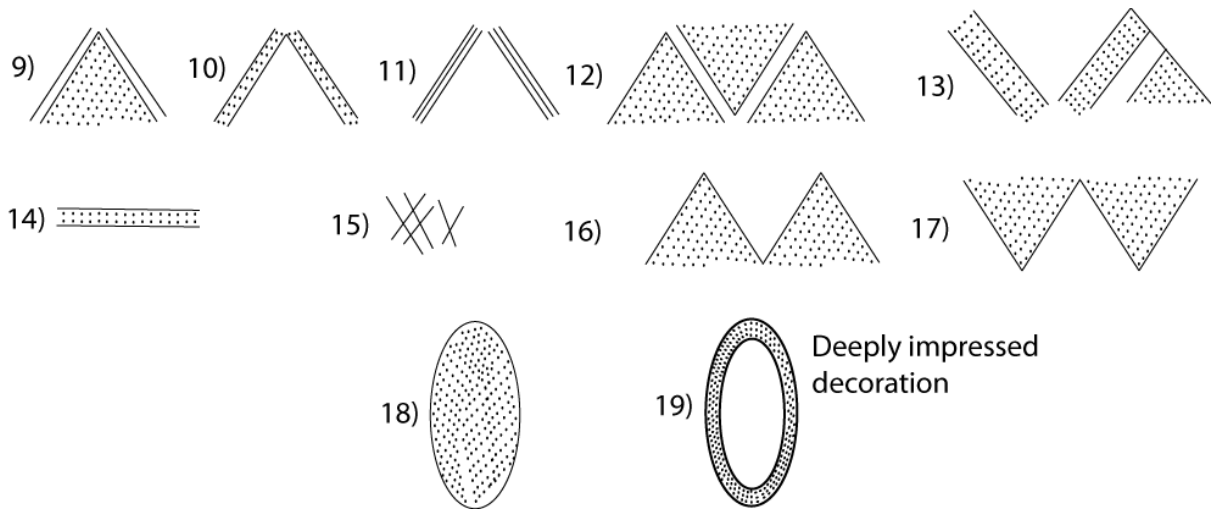
CHAR: 8

Lines delineating the decorative motifs and dividing the body into decorative segments.

This character refers to the practise of using a pointed tool to create delineating lines in the leather hard clay to indicate the areas to be filled with the decorative motifs and impressed dots (comb or single pointed tool).

0 = absent, 1 = present.

Decorative motifs: all binary: 0 = absent, 1 = present.



CHAR: 9

A standing triangle with double incised lines where the triangle is filled with impressed dots.

CHAR: 10

A standing triangle with double incised lines where the area between the double incisions is decorated with impressed dots.

CHAR: 11

Standing triangles created by three parallel incised lines on each side.

CHAR: 12

Alternating standing and pending triangles filled with impressed dots.

CHAR: 13

Irregular diagonal bands filled with impressed dots.

CHAR: 14

A horizontal band filled with impressed dots.

CHAR: 15

Irregularly incised lines. A more or less random pattern of lines.

CHAR: 16

Standing adjoining triangles filled with impressed dots.

CHAR: 17

Pending triangles filled with impressed dots.

CHAR: 18

Lozenges, created by incising adjoining rounded lines on a round or oval vessel in mirror position, filled with comb impressed dots.

CHAR: 19

Double oval incised lines in which the space between these lines is filled with deeply impressed dots. It is likely that this was done while the clay was still fairly plastic (before drying to the leather hard stage). As such, it might be the result of an unintentional action where a similar pattern as with lozenges as in character 18 was desired but the vessel wall was impressed while applying the comb decoration.

Matrix_Globular_17taxa

N1 1211?11111100000000
N2.1b 1221120110000100000
N2.1c 1221121110100000000
N3.1a 1223031100010001000
N3.1b 1224131100010000100
N4.1a 1141020100001000000
N4.1b 1141020110000000000
N4.1c 11410?0110000100000
N4.1d 11?1020110000000000
N5a 1221020100000100000
N5b 1224021101000100000
N6 1243030100000010000
L9.1a 2233030100000001100
L9.1b 2234030100000001100
L9.4a 2234030100000000010
L10 2234030100000000001
L9.5 2234030000000000010

Appendix 4: Jericho Tell el-Yahudiya juglets

The table below gives information on the amount of juglets found in Middle Bronze Age tombs from Jericho mentioned in Kenyon's (1960; 1965) publications on the tomb. The table shows the number of juglets by category: piriform juglets, cylindrical juglets, other juglets, and juglets decorated in the Tell el-Yahudiya style. Separate columns show the approximate number of interments, and the number of juglets per person based on these estimates.

TOMB	Piriform juglets (Red/Brown slipped)		Cylindrical juglets		Other juglet		TE Y		TOT AL	%	Approximate number of interments	Juglets/ Person	Reference
	CO M	INCOM	COM	INC O M	C O M	INC O M	CO M	IN C O M	jugle ts	TEY		estimate	
GROUP I													
A1	7	4	1						12		8 or 9	0.75	Kenyon 1960, 302
J3	3	6			1				10	10	1	0.1	Kenyon 1960, 308
GROUP II													
G37	13	12				1	2	1	29	10	19	1.53	Kenyon 1960, 315
G46	14	10	1						25		16	1.56	Kenyon 1960, 330; Kenyon 1960, 332 on the number of individuals
GROUP III													
A38	17	26	2				1		46	2	5	9.2	Kenyon 1960, 342
A34	17	27	4	1			1		50	2	7	7.14	Kenyon 1960, 352
B35	23	50	2	1					76		At least 23 (skulls). Mult. interments in different layers. 3 (upper layer)	3.3	Kenyon 1960, 368
B3	27	13	2				1		43	2	At least 20 (skulls A-T)	2.15	Kenyon 1960, 393
A46	4	1	2	1			1		9	11	14	1.56	Kenyon 1960, 407
GROUP IV													
J9	1	3	4						8		22	0.36	Kenyon 1960, 410
J12	7	4	7	5			1		24	4	13	1.85	Kenyon 1960, 418

J1	4	3	5	2					14		At least 25 (Skulls A-Y)	0.56	Kenyon 1960, 425
GROUP V													
J7			4						4		13	0.31	Kenyon 1960, 438
G1	1	1	4	2		1		1	10	10	At least 16 (A-V). 7 in extended position, earlier layer of burials	0.63	Kenyon 1960, 443
H6	1	4			3				8		At least 7. 4 (latest phase)	0.86	Kenyon 1960, 453
H11	1		3	1					5		At least 13 (skulls A-M)	0.38	Kenyon 1960, 470
H13			6	1					7		At least 18 (A-R)	0.39	Kenyon 1960, 479
H18			1						1		13	0.08	Kenyon 1960, 486
H22			2	2					4		12 (4 adults and eight children)	0.33	Kenyon 1960, 500
B12 (probably robbed)											no info		Kenyon 1960, 513
A12											no info		Kenyon 1960, 514
G33											no info		Kenyon 1960, G33
A15			1						1		no info		Kenyon 1960, 517
Jericho II publication													
MBI tombs													
K3	2								2		16	0.13	Kenyon 1965, 203
MB Group I-II													
B48	27		1						28		9	3.11	Kenyon 1965, 206
MB group II													
M11	16	2	3						21		7	3	Kenyon 1965, 226
D22	23	1	1	1					26		1	26	Kenyon 1965, 242

J54	22								22		1	22	Kenyon 1965, 260
J37	9								9		unknown		Kenyon 1965, 269
D6	2	3					1		6	17	Unknown total amount. 1 better preserved (skull A).		Kenyon 1965, 274
D9	18	3							21		10	2.1	Kenyon 1965, 276
P23	3	1							4		8	0.5	Kenyon 1965, 286
P1	4	3							7		24	0.29	Kenyon 1965, 295
B50	3	5					1		9	11	13	0.69	Kenyon 1965, 303
J14	8	1	5					1	15		15	1	Kenyon 1965, 313
GROUP III													
B51	21	1	11				1	2	36	8	37	0.97	Kenyon 1965, 332
P17	6		1				2		9	22	18	0.5	Kenyon 1965, 359
A134	2		4				2		8	25	13	0.62	Kenyon 1965, 368
J19	8	3					1	1	13	15	19	0.68	Kenyon 1965, 372
G82	3	2	2	1					8		1 individual preserved, other fragmentary		Kenyon 1965, 382
P19	1								1		7	0.14	Kenyon 1965, 388
J20	5	3	4	1			3	2	18	28	18 (2 complete bodies, 16 skull count of fragmented bodies)		Kenyon 1965, 410
J42			1						1		At least 3 (all children, crushed bones)		Kenyon 1965, 420
D13			1						1		Unknown (Very fragmentary)		Kenyon 1965, 424
P21			1						1		3	0.33	Kenyon 1965, 428
GROUP IV													
J45	5		25	1			1		32	3	26 (skull count: p. 438)		Kenyon 1965, 438
G73		1	6	1				1	9	11	26	0.35	Kenyon 1965, 447

GROUP V													
A136			14						14		26	0.54	Kenyon 1965, 465
J39			13	1			1		15	7	17	0.88	Kenyon 1965, 473
TOTAL	328	193	144	22			20	9	722	3.91		2.56	average

Appendix 5: Wadi Suq pendants

Pendants outside of south-east Arabia:

Quetta

Bulls: National Museum Karachi SHQ 01, 02 (after Kenoyer 2003, 283, Fig. 270a-b).

Size

- a. H. 5.4 cm; L. 7.2 cm
- b. H 5.2 cm; L 7 cm

Material: Gold.

Description: According to Kenoyer (2003, 383-384): The bull ornament has been made using a variety of techniques, including “raising, chasing and joining. The hollow body may have been hammered out into a hollow mould to chase the details of the face and body, and then filled with resin. The horns, ears, and tail are all joined to the body without use of solder. The back of the ornament was attached by crimping the edges over the front, also without solder. Two loops are attached to the back to facilitate attachment to a necklace or head ornament.”

Context: These miniature bulls were found within a ‘cenotaph’ like context in a ‘rescue’ excavation situation at Quetta. After Kenoyer 2003, 383-384: “These two miniature bull figures were found in a hoard associated with a burial, along with a large collection of gold ornaments, a gold cup or chalice ..., pottery, and carved stone ritual objects, all of which can be dated to about 2000-1900 BC. The bull pendant was part of a rich deposit of good associated largely with central Asian (Oxus) civilization burials. The context is dated generally to the start of the 2nd millennium related to the Bactria-Margiana/Oxus civilization.”

The bulls are almost identical to the necklace found at Gonur Tepe, however here, the bulls are facing each other and placed on a bar, and the animals are inlaid with precious stones (see below).

References: Jarrige and Hassan 1989; Kenoyer 2003, 383:270a-b.

Condition: Complete.

Image: Kenoyer 2003, 383: Fig. 270a-b

Phylogenetic reference: Quetta bulls

Gonur Tepe

Material: Silver (covered). Inserted with semi-precious stones.

Description: The pendant is formed by two bulls on a horizontal bar. It is approximately 10 cm in length. It shows carefully cast features and is covered by silver and inserted with semi-precious stones. Like the Quetta bulls, it is likely made with a combination of techniques, and the horns seem to have been separately cast and inserted. Similar to other ornamental pieces from this region, it has been inserted with semi-precious stones, distinguishing it from the Quetta bulls. These semi-precious stones might however been added at a later stage.

Context: Found in a burial context with an elderly male in a mudbrick tomb at Gonur Tepe apparently associated with later phases of use (other finds from the tomb). A C-14 date: 3350 +/- 70 BP, is mentioned (Sarianidi 2007, 147) for this tomb dating it at 1736-1533 cal BC 68.2%; 1876-1457 cal BC 95.4%: (Oxcal 4.2 and IntCal 13 calibration curve: Bronk Ramsey 2009; Reimer *et al.* 2013). This date might however be problematic as it is not specified what is dated (old wood effect). If the date is correct, the pendant can still have functioned as an heirloom (a general problem with these pendants) and be more ancient than its burial context.

Date: 2nd millennium (BMAC), probably an heirloom.

Condition: Complete.

Image: Sarianidi 2007, 150; 151: Fig. 29; a better quality image was provided by Prof. N. Dubova and is property of Margiana archaeological expedition.

Phylogenetic reference: Gonur Tepe bulls.

Hamala

During Caspers 1986, 39: Plate I.1

Description: A pendant in the shape of a goat. It appears to be cast in a mould. This pendant is possible a re-used pinhead. It is very similar to pinheads of BMAC culture (Sarianidi 2007, 89). The fact that it is made of copper-alloy would suggest this even more so.

Context: Dilmun burial.

Condition: Corroded but seemingly complete.

Phylogenetic reference: *Hamala caprid*.

Image: During Caspers 1986, 39: Plate I.1

Pendants from south-east Arabia.

Tell Abraq

TA 2280 (ca nr 210a): red gold. H 2.03 cm, L 1.98 cm, TA 2280

Reference: Potts 2003; 2000a; 2000b.

Material: Gold

Description: A gold pendant in the shape of a ram showing detailed rendition of the muscles and other features. The pendant is likely cast in a single-mould and further details are later engraved. Two semi-circular loops are attached to the back of the animal (Potts 2003, 313: Fig.210a).

Context:

The two illustrated pendants were found in the late Umm an-Nar tomb at Tell Abraq (Potts 2000a; 2000b; Potts 2003) The tomb dates to the end of the 3rd millennium (ca. 2200-2000 BC) and yielded the remains of approximately 400 individuals, and a large amount of ceramic vessels, stone vessels and jewellery. Of these, numerous examples could be shown to yield from the area of Baluchistan/Southeast Iran. Further ties to the Central Asian (Oxus river civilization) were shown by a comb with tulip design, and a number pedestalled ceramic vessels (Potts 2000a; 2000b). No specific connection is mentioned between the pendants and certain individuals. Interesting, in one article, Potts (2000b) mentions two more animal ‘pendants’ of a dog and caprid, yet these were never illustrated by the excavators.

Date: Late Umm an-Nar period.

Condition: Complete.

Image: Potts 2003, 312: Fig. 210a.

Phylogenetic reference: Abraaq caprid.

2) TA 2457 (ca nr 210b). H. 2.01 cm; L 3.3 cm.

Material: Red gold.

This pendant depicts two ‘shorthaired wild sheep’ with large curving horns which Potts identifies as *Ovis vignei* which are typical for the Iranian and Central Asian region (Potts 2003, 313). Significantly, the animals are forward facing. The animals stand on a bar with the hind legs touching. This pendant was likely cast in a uni-facial mould and subsequently smoothed and incised. The pendant has two semi-circular soldered loops on the back to suspend it as a necklace or attached it to garment.

Condition: Complete.

Date: Late Umm an-Nar period.

Image: Potts 2003, 312: Fig. 210b

Phylogenetic reference: Abraaq ovis.

Qattarah

In total, five pendants are known from this ‘Shimal’ type tomb from Qattarah in the al-‘Ain oasis. Four were excavated in the seventies, and another pendant was retrieved in later excavations by Walid al-Tikriti in 1988, yielding another golden pendant of double caprids (1989, 104). The latter was found with a ‘dozen’ of copper alloy ‘swords’, baskets/buckets, arrowheads, socketed spearheads, and stone and ceramic vessels. It might be suggested that at least part of the finds came from a ‘cache’ like situation (Carter 1997). However, lacking more detailed contextual descriptions this remains tentative.

1: Caprid 1

Material: Gold.

Size: approx. L. 6.5; H 4.06 cm.

Description: Double caprid. Cast with fine features. It shows evidence of annealing, and repoussé employed. Body is divided into segments by incised lines. Male features are indicated by serration. Separate line visible around neck. The eyes are round and added by annealing. The caprid has four legs, separated by inner line, and placed on a horizontal bar. The legs are incised with chevrons, and the back is ridged and incised with lines.

Preservation: Almost complete, one pair of legs missing.

Image: Al-Tikriti 1989, Pl. 74B

2: Caprid 2

Material: Gold

Size: approx. L 6.74; H 5.14 cm

Description: Double caprid pendant with very abstract in features. It shows evidence of hammering, repoussé technique with annealing. The heads are not clearly indicated and have large looped 'ears' separately added. The body shows evidence of substantial folding and hammering around features. The caprid has six legs and a horizontal bar separately added. The tail is separately made and consists of a double spiral and is separately added. The body and horizontal bar are decorated with incised/impressed chevrons.

Preservation: almost complete.

Image: Al-Tikriti 1989, Pl. 74C

3: Caprid 3

Material: Electrum

Size: approx.. L 10.8 cm; W/D: 4.5 cm.

Description: Double caprid. Techniques uses on these pendants are hammering, repoussé and annealing. This caprid is an elaborately decorated example. The heads have indicated mouths with an incised line. The ears are annealed and formed by large

loops. The eyes are circular and separately added. The body is divided into six segments by incised lines and repoussé technique. The animal has six legs with a horizontal bar added to them separately. All around the body are rings, similar to other serrated examples. The legs, necks and horizontal bar are decorated with incised chevrons. One large tail is formed by a double spiral, and two more double spirals are placed on the backs of the double goat.

Preservation: complete

Image: Al-Tikriti 1989, Pl. 74D

4: Bull

Material: Silver

Description: Single bull. It is likely cast in a mould. The head is cast *en profil*. The bull has double cast legs separated by a later incised line. The male sex seems indicated. Although not well cleaned and photographed, it seems very similar to the Qarn al-Harf example.

Image: Cleuziou 1979, 44.

5: Lion

Size: From image: 4.9 cm L; 4.1 cm W.

Material: Likely silver.

Description: Lion or dog? Cast and extensively hammered, with repoussé technique and annealing of the mouth. The legs are double and separated by a line. It bears serrated decoration indicating manes or hair, also typical of other Wadi Suq double caprid pendants.

Image: Cleuziou 1979, 44.

Context: The tomb underwent two excavations but has not been sufficiently published (Carter 1997, 37-38). In total, five pendants are known from this 'Shimal' type tomb from Qattarah in the Al-'Ain oasis. Four were excavated in the seventies, and another pendant was retrieved in later excavations by Walid al-Tikriti in 1988, yielding another golden pendant of double caprids (5) (al-Tikriti 1989, 104). The

latter was found with a large number of metal goods, of which a ‘dozen’ of copper alloy ‘swords’, baskets/buckets, arrowheads, socketed spearheads, together with stone and ceramic vessels (Carter 1997a, 38). It might be suggested that at least part of the finds came from a ‘cache’ like situation. However, lacking more detailed contextual descriptions this remains tentative.

Date: The context of the deposit is Wadi Suq in general, but considering the ‘cache’ nature of the deposit, it is likely that the date of the pendants can be quite diverse, some dating to the start of the Wadi Suq, others to the late Wadi Suq.

References: Cleuziou 1979, Al-Tikriti 1989, Carter 1997

Images: Cleuziou 1979, 44; Al-Tikriti 1989, Plate 74.

Qarn al-Harf

1: Lion: QAH6-SF053.

Size: L 4.7 cm; W. 3.6 cm; T: 0.6 cm

Material: Silver

Description: Cast in an open mould. Fine features cast and accentuated with incised lines. The lion has a head with large eye, oval ear and open mouth with teeth accentuated and tongue rolling out. The front and back of the neck shows serrated manes/hair. The back shows a sharply demarcated line ending in a curled tail. The legs are cast as two segments separated with a sharp line. The male sex is indicated, and a testicle is visible between hind legs and tail. The muscular features are accentuated with lines and fine decoration in bands with diagonal lines are incised on the neck. Two rings formed by triple rings are added to the back.

Context: Found within Qarn al-Harf tomb 6. The pendant was found within a hoard with numerous semi-precious stone beads and silver and gold beads including two quadruped spiral beads (Weeks *forthcoming*). Qarn al-Harf tomb 6 is architecturally a transitional tomb from the Umm an-Nar circular tomb tradition and early ceramic types (transitional) are attested from the tomb as well. The hoard of precious metals and beads is paralleled in other contexts (see Shimal, Dhayah and Qattarah).

Condition: Well preserved. More or less complete.

Date: Early Wadi Suq.

2: Bull: QAH1-SF025.

Size: L 4.7 cm; W. 3.6 cm; T: 0.6 cm.

Description: Bull cast within an open mould. Finely cast features accentuated by later incised lines. The bull has a single horn. No eyes are indicated. Incised lines are added around the stump nose. The neck is slightly raised and woolly hair is indicated by incised lines. The legs are cast in twofold and separated with incised lines. The male sex seems indicated on the belly. A fine line demarcates the upper back and backside of the animal. A ring of threefold lines is added to the back. Another possibly missing.

Context: Found within Qarn al-Harf tomb 1.

Condition: Well preserved. More or less complete except for hole in mid-body, possibly due to casting.

Date: Early Wadi Suq period.

Images: Weeks *forthcoming*, Derek *forthcoming*. Used with permission of the Qarn el-Harf project.

3: Lion: QAH2-SF14

Size: L 4.0; W. 3.8; T: 0.4

Context: Found within Qarn al-Harf tomb 2.

Description: Lion (or dog?). The pendant is created by hammering, repoussé, annealing and incision. The body shows evidence of repoussé to create relief. The head shows sharp ears, a circular eye which is separately added, and a mouth created by a U-shaped line and teeth indicated by two small bars, separately annealed. The tail curves upwards back to the body (perhaps indicative of a dog?). The body is serrated with sharp hammered incisions to decorate it, and hammered points on the neck and around the head and mouth. The male sex seems indicated on the belly. A single loop is added at the back at the height of the neck. This pendant is very similar in to the ones found at Qattarah and Dhayah.

Condition: Well preserved. More or less complete.

Images: Weeks *forthcoming*, Derek *forthcoming*. Used with permission of the Qarn el-Harf project.

Phylogenetic reference: 1: QAH lion; 2: QAH bull; QAH2 lion.

Shimal

Shimal 99: SH99MT03

Size: H/L 8.2 cm; W/D: 4.5 cm

Material: Electrum.

Description: Antithetical caprid. It was cast and extensively treated afterwards, showing repoussé and annealing. The figurine bears two heads with separately added circular eyes and large loop-shaped ears. The body is divided into six segments by incised lines. The animal has six legs placed on a horizontal bar. The side of the animal is serrated, indicating wool or hair, and bears incisions. The necks of the animal bear zigzag incisions. The tail is formed by a double spiral. Two small spirals are added at the end of the feet on the horizontal bar.

Context: Found within a metal hoard within Shimal tomb 99 (Velde *forthcoming*).

Image: Velde *forthcoming*, 205.18.

Phylogenetic reference: Shimal caprid.

Shimal 600

Apparently, two silver animal pendants were found in Late Wadi Suq context within Shimal 600 but await further publication (Vogt 1998, 279). Shimal tomb 600 is believed to be relative late in the sequence (Velde pers com). It would be highly interesting to see what kind of pendant was found in this tomb. No further information is available on this pendant at the moment.

Dhayah

Caprid: H: 11.1; W: 6.6 cm.

Material: Gold/electrum

Description: Antithetical caprid with 6 legs and attached horizontal bar. The pendant was cast in an open mould and extensively hammered and incised afterwards to render details. The body shows four segments indicated by incised lines. The eyes are round and separately annealed. Looped ears were separately attached. The body is serrated and bears extensive chevron incisions. The tail is formed by a double spiral. Five separate loops are added to the bar between the legs.

Context: K13. Found within ancillary structure to tomb DH2, in a stone feature built against the outside of the tomb. A cache of metal goods including two socketed spearheads and caprid (what about lion?) (Kästner 1991, Velde *forthcoming*).

Image: Velde *forthcoming*, Plate DH2.9

Lion: RAK 3771/DH002MT02

Size: From drawing: Preserved: L 10.7. Individual animal 6.7 (in case of symmetry +/- 13.4 cm) ; W preserved 4.8 cm

Material: Silver.

Description: A double lion (or dog?) pendant. The pendant was cast in an open mould and extensively hammered and incised afterwards to render details. The eyes are round and separately added. The teeth and mouth seem separately annealed. The animals have two preserved legs. The tail curves back to the body. The body is serrated and bears incisions, partly chevron at the neck. The animals seem separately added to a metal strip, and the strip shows a double spiral (usually functioning as the tail with the double caprid pendants).

Context: K13. Found within ancillary structure to tomb DH2, in a stone feature built against the outside of the tomb. These pendants were found in a cache of metal goods including two socketed spearheads (Kästner 1991, Velde *forthcoming*).

Condition: Fragmented (broken approximately in half).

Image: Velde *forthcoming*, Plate DH2.10.

Phylogenetic reference: 1: Dhayah caprid; 2: Dhayah lion.

Bidya

Caprid: Al-Tikriti 1989D

Size: approx. L 7.6 cm; H. 4.8 cm.

Material: Gold, and silver annealing

Description: A double caprid pendant, with caprids being antithetically placed and sharing the body. The main body is cast and shows extensive treatment by hammering, repoussé and incisions. The eyes of the caprids are round and separately added. The ears are formed by annealed loops. The body is separated into four segments by incised lines. The animal has six legs which are placed onto a horizontal bar. The body is serrated and shows incised decoration in the form of chevrons, lines and dots. The tail, usually formed by a double spiral, is simplified into and part of the serration of the body. At a later stage, a silver coating was used to cover part where the legs and horizontal bar were annealed.

Context: Found within a 'Shimal' type tomb of 30.7 x 2 m long (al-Tikriti 1989). Most of the tomb is purported to be below ground, with 40 'neatly laid flagstones' resulting in a subterranean flooring. These types of Shimal tombs are purportedly later in the sequence. The pendant is found in the upper chamber of the tomb, as well as three socketed spearheads, fourteen stone vessels and four ceramic vessels. Six copper alloy baskets were found in the lower chamber in the subterranean floor, as paralleled at Qarn al-Harf (QAH2A). No exact information on the location or relation with the approximately 12 individuals (based on minimum number of skulls) (al-Tikriti 1989).

Condition: Fairly complete.

Image: al-Tikriti 1989: Pl. 74A; Pl. 95B

Phylogenetic analysis: Bidya caprid.

Jebel Buhais

SM1997-262.

Preserved L. 044, H. 0.37 cm

This pendant is fragmented and shows a well-cast animal; probably cast in a single-mould, with clear details visible in muscles and hair. It features a beak (like a bird of

prey) and lion-like manes and body. Before thorough cleaning, the pendant was initially reported to be a caprid (Jasim 2012, 63), but on closer inspection it turns out to be a hybrid animal (most likely a form of griffin, see also Page and Rerolle 2015). Two loops are added to the back (Page and Rerolle 2015). The dating of the pendant, considering the context, can be placed relatively early in the Wadi Suq period, as a near complete spouted jar shows a well slipped surface and decoration of small pending loops and strokes which can be seen as early in the ceramic sequence.

Context: The pendant was found on the floor of the burial chamber of an early subterranean u-shaped Wadi Suq tomb (JB12) at Jebel Buhais (Jasim 2012, 63).

Date: Early Wadi Suq.

Condition: Fragmented/broken (Possibly intentionally fragmented?) Recently cleaned by Sharjah Museum staff (Page and Rerolle 2015).

Image: Page and Rerolle 2015. Used with permission of the Sharjah Museums Department.

Phylogenetic analysis: Buhais griffin.

Character list Pendants

Char 1: Size group:

- 1) up to 4 cm in height and under 5 cm in length
- 2) over 4 cm in length and over 4 cm in height.

Char 2: Material

- 1) Gold/Electrum; 2) Silver; 3: Copper alloy

Char 3: Type of animal

Caprid 1; ovis 2; bull 3; feline/dog 4; 'griffin': 5

Char 4: Technique

- 1: Cast single mould and incised; 2: Hammered, rebousse

Char 5: Single or pair

- 1 single, 2 pair fastened 3: pair loose

Char 6: Attachment

- 1) loops above pendant; 2) loops attached to back

Char 8: Legs

- 1) double separated; 2) single cast back and front separated by line; 3) 6 legs, hind-legs as one

Char 9: Accentuated line back (traced with tool)

0 = NO; 1 = YES

Char 10: Spirals as decorative element

1: no spirals; 2: added with tails; 3 functioning as tail; 4 functioning as tail and additional spirals; 5: spiral abstracted

Char 11: Style of the eye.

1) not accentuated; 2 cast; 3: full circle; 4: punctured dot; 5: circular with central dot

Char 12: Style of the ears

1) cast separately; 2: oval; 3 double loop; 4 not indicated

Char 13: Indication teeth

1) no teeth, 2) separately cast; 3: added as bar

Char 14: Horizontal bar on which the animals are attached

0 = absent; 1 = present

Char 15: Loops attached:

0 = absent; 1 = present

Char 16: Decoration/Incision

1) no incised lines/cast; 2 accentuating lines; 3) dots, chevrons and diagonal lines

Char 17: Serrated sides

0 = absent; 1 = present

Char 18: Male sex indicated

0 = absent; 1 = present

Char 19: Infilled with precious stones

0 = absent; 1 = present

Matrix_WSPendant_trial2

'Abraq_caprids'	1111122101111102010
'Abraq_ovis'	1121221201411001010
'Hamala_caprid'	1311122101??1101010
'Quetta_bulls'	1131321101221001010
'Gonur tepe_bulls'	?231311101211101011
'QAH_bull'	1131122211141001010
'QAH_lion'	1141122211322002110
'Buhais_griffin'	2251222212121002010
'Qattarah_bull'	22311?2211141002010
'QAH2_lion'	2142122211523003110
'Qattarah_lion'	2142122211341002110
'Qattarah_caprid1'	2112222213521103010
'Qattarah_caprid2'	2112222303131103000
'Qattarah_caprid3'	2112222314531123000
'Shimal_caprid'	2112222314531103100
'Dhayah_caprid'	2112222313531123100
'Dhayah_lion'	2242222212533103110
'Bidya_caprid'	2112222305531103100

Appendix 6: WS spouted jars phylogenetic dataset

Cladistic dataset_WS_SJGROUPS

General: The characters are either multi-state (1,2,3,4) or binary (0 or absent). A question mark '?' signifies the data is absent for a particular taxon.

The dataset consists of 16 taxa, consisting 60 vessels. 22 characters have been defined.

CHAR: 1: General Body Shape

- 1) Globular 2) squat

The general shape of the body part of the vessel has been defined as either Globular, with a rounded body shape and approximately similar height to width ratio, or 2) squat, showing a distinct profile with a wider maximum circumference than height.

No detailed metrical definition was used due to two main reasons. 1) the fragmentary state of the vessels. With a larger dataset of more completely preserved vessels, more detailed metrical data should be obtained in order to help establish these categories. 2) the diversity in shape showing variety in body shapes, but within the broader category of either globular or squat shapes.

CHAR: 2: Type of Spout

1) u-shaped 'trough' spout attached to the rim. The spout is made by folding a piece of clay (perhaps around an object or finger, and inserting it through a hole cut just below the rim. The spout is subsequently added to the rim of the vessel creating a trough. The spout is fairly elongated and can be slightly curved.

2) u-shaped spout attached slightly below the rim. The spout is similar to character 1 but is attached slightly below the rim, it has a distinguished pinched part where the spout joins the vessel wall.

3) u-shaped spout added to the shoulder. The spout is separately made with a slab of clay and inserted through a cut hole in the vessel wall. However, the spout has a marked 'trumpeted' shape and with an oval outlet and is pinched at the top.

4) tubular spout. This type of spout is tubular shaped and attached to the shoulder of the vessel by piercing a hole through the wall and adding the separately formed cylindrical clay fragment.

5) a short u-shaped spout attached on the shoulder. This spout is distinct from type 1 as it is shorter in length and placed on the shoulder.

CHAR: 3: Rim type

- 1) Inward facing. The rim is folded over and flattened.
- 2) Thin rim with slightly everted lip.
- 3) Folded everted rim.
- 4) Folded and pinched rim.
- 5) Folded pinched rim with marked thick upper part (hammer rim)
- 6) Folded rim with groove created by pinching part of the lip.

CHAR: 4: Finishing of the base

Bases are either individually made as a round disk or at a later stage made on the wheel and string-cut. However, these features were not always clearly recognizable. The data has been coded in terms of 1) clearly recognized smoothed and possibly slipped, or left unsmoothed with traces of scraping excess clay away.

- 1) Smoothed
- 2) Shaved. The base shows traces of shaving/scraping excess clay from the body.

CHAR: 5: Slip/Ware

- 1) Fugitive light red slip and heterogeneous temper rich in wadi pebbles, limestone
- 2) Well applied red or red brownish slip. Rather fine ware with limestone, silicate pebbles and limited vegetal temper.
- 3) Crème slip, likely a salt/scum slip which is possibly naturally present in the clay. A red firing iron-oxide rich slip is no longer purposefully added. The fabric is finely tempered with limestone (CaCO₃) and vegetal temper visible as elongated pores.

CHAR: 6: Fabric

- 1) Fine ware
- 2) Rich in limestone. Gritty fabrics (9b and 13)
- 3) Fine lime sandy ware (fabric 2, 3 and 4)

4) Vegetal temper dominant (1 and 11)

CHAR: 7: Firing

1) Oxidizing: fired under oxidizing atmosphere

2) Neutral: Fired under neutral atmosphere.

3) Sandwich: with a reduced core

Decorative characters

CHAR: 8: Lines painted on the rim of the vessel

0) No lines

1) Continuous line

2) groups of thin lines perpendicular to the rim

CHAR: 9: Delineating lines demarcating the decorated area added below the rim and midway the body of the vessel

0) no delineating lines

1) 1 delineating line

2) 2 delineating lines

3) 3 delineating lines

4) 4 delineating lines

CHAR: 10: Small loops, possibly with pending strokes

0) Absent or 1) present

CHAR: 11: Hanging and standing loops between vertical lines

0) Absent or 1) present

CHAR: 12: Zigzag chevrons > 3

0) Absent or 1) present

CHAR: 13: Zigzag chevrons < 3

0) Absent or 1) present

CHAR: 14: Horizontal wavy bands

0) Absent or 1) present

CHAR: 15: Horizontal lines

0) Absent or 1) present

CHAR: 16: vertical wavy lines, or horizontal wavy lines between straight lines

0) Absent or 1) present

CHAR: 17: Adjoining triangles net-filled

0) Absent or 1) present

CHAR: 18: lines with short cross strokes/barbed wire

0) Absent or 1) present

CHAR: 19: Lines with short cross lines

0) Absent or 1) present

CHAR: 20: Diagonal group of chevrons

0) Absent or 1) present

CHAR: 21: Ibex

0) Absent or 1) present

CHAR: 22: Human figures

0) Absent or 1) present

Matrix_SJGROUPS_data_coding

GROUP_1	1?11113020000000000110
GROUP_2	1511121011100101001000
GROUP_2b	141?121030000000000010
GROUP_3	1441231330000001000000
GROUP_4	1132221031011000001101
GROUP_5	1141243220111000001000
GROUP_6	1141243240000000001101
GROUP_7	1142242220001000000000
GROUP_7b	2121243020001000000000
GROUP_8	1162341220000110000000
GROUP_8b	2122343210000100000000
GROUP_9	1242333220011100100000
GROUP_10	1352243210000100110000
GROUP_11	1342343220000100000000
GROUP_12	1342242220100000000000
GROUP_13	1352343000000000000000

Appendix 7: Phylogenetic dataset general beakers/cups

Cladistics WS_Beakers_Gengroup_6.

Using dominant absent/presence coding to derive to a larger number of characters and allow for variety within the 6 dominant groups. This approach is taken to allow for a more general number of taxa representing dominant ceramic traditions in making cups and beakers, and show the variability of characters. As such, all character states have the potential to be present in the various groups. However, the separate character states do represent alterations in the potters technique for distinct features such as finishing the rim, the base, etc.

Character list

CHAR 1:

- 1) Wide shaped body
- 2) Elongated profile, straight sided walls
- 3) Oval shaped walls
- 4) Wide with straight walls
- 5) Inverted walls

CHAR 2: Straight rim

CHAR 3: Slightly everted rim

CHAR 4: Everted rim

CHAR 5: Smoothed base

CHAR 6: Shaved base

CHAR 7: String-cut base

CHAR 8: Slip present

CHAR 9: Slip absent

CHAR 10: Firing OX

CHAR 11: Firing NEU

CHAR 12: Firing SW

CHAR 13: Firing RED

CHAR 14: Delineating lines 3>

CHAR 15: Delineating lines 2

CHAR 16: Delineating lines 1

CHAR 17: No delineating lines

Decorative motifs

CHAR 18: Thin wavy horizontal lines

CHAR 19: diagonal chevrons

CHAR 20: vertical lines with vertical wavy lines

CHAR 21: vertical lines with single wavy line

CHAR 22: Vertical thick lines

CHAR 23: hanging loops and short strokes

CHAR 24: vertical lines with hanging and standing loops

CHAR 25: vertical lines with vertical loops along lines

CHAR 26: horizontal lines with loops attached

CHAR 27: 4-5 zigzag chevrons

CHAR 28: 3 zigzag chevrons

CHAR 29: 2 zigzag chevrons

CHAR 30: Thin attached triangles: 'butterfly'

CHAR 31: empty space between vertical delineation

CHAR 32: vertical lines

CHAR 33: wavy vertical lines

CHAR 34: Thick wavy lines

CHAR 35: double dots

CHAR 36: vegetal motif

CHAR 37: net-pattern

CHAR 38: attached triangles filled with net-pattern

CHAR 39: groups of vertical and diagonal lines

CHAR 40: Group of vertical lines

CHAR 41: Rilling

Matrix_WS_GENGROUP_6

Outgroup 1100110101100011011000000000000000000000

Group_1 1100100111100111000111000000000000000000

Group_2 21101101111101101000001111110110100000000

Group_3 31101001111111101000000000000001100000101

Group_4 4111111111111110000000000011000011110000

Group_5 5011011111111110000000100000000000111110

Appendix 8: Phylogenetic datasets specific beaker and cup types

Cladistic dataset_WS_beakers_22taxa

22 taxa, 23 characters

CHAR 1: General shape categories

- 1) Wide shaped body
- 2) Elongated profile, straight sided walls
- 3) Oval shaped walls
- 4) wide with straight walls
- 5) Inverted walls

CHAR 2: Rim-shape

- 1) Straight rim
- 2) Slightly everted
- 3) Everted rim

CHAR 3: Base

- 1) Smoothed base.
- 2) Shaved base.
- 3) String-cut base

CHAR 4: Slip

- 1) Red or red-brown slip added, 2) light scum/salt-slip surface

CHAR 5: Delineating lines below the rim and 2/3 body which demarcate the decorated area.

- 0) No delineating lines, 1) one delineating line, 2) two delineating lines, 3) 3 delineating lines

Decorative motifs

CHAR 6: Chevrons

CHAR 7: Thin wavy lines

CHAR 8: vertical lines and multiple wavy lines

CHAR 9: pending loops and lines

CHAR 10: vertical lines and loops

CHAR 11: vertical lines and diagonal loops

CHAR 12: vertical lines and pending loops

CHAR 13: vertical lines, triangles and lozenges

CHAR 14: butterfly motif

CHAR 15: 3 or > zigzag chevrons

CHAR 16: 2 zigzag chevrons

CHAR 17: vegetal/branch motif

CHAR 18: net-pattern

CHAR 19: vertical lines

CHAR 20: triangles filled with net-pattern

CHAR 21: thick double wavy lines

CHAR 22: thick lines just below the rim

CHAR 23: rilling

1.1	11112010000000000000000000
1.2	11112100000000000000000000
1.3	21113001000000000000000000
1.4	21113000100000000000000000
1.5	21113000010000000000000000
1.8	31112000000100000000000000
1.10	31113000001000000000000000
1.12	21210000000000000000000001
1.14	31110000000000000000010000
2.1	42113000000100000000000000
2.1.1	42113000000010000000000000
2.2	32113000000001000000000000
2.3	32113000000000000000000000
2.4	32113000000000010000000000
2.5	32103000000000010000000000
3.1	32202000000000010000000000
3.2	32202000000000001000000000
3.3	32202000000000000100000000
3.4	522020000000000000000001000
3.5	5220200000000000000000000100000
3.7	4330200000000000000000000100
3.8	4330000000000000000000000010

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